ARROW ENGINE COMPANY™

a TRIMAS company

VR 220 330

SERVICE OPERATION PARTS

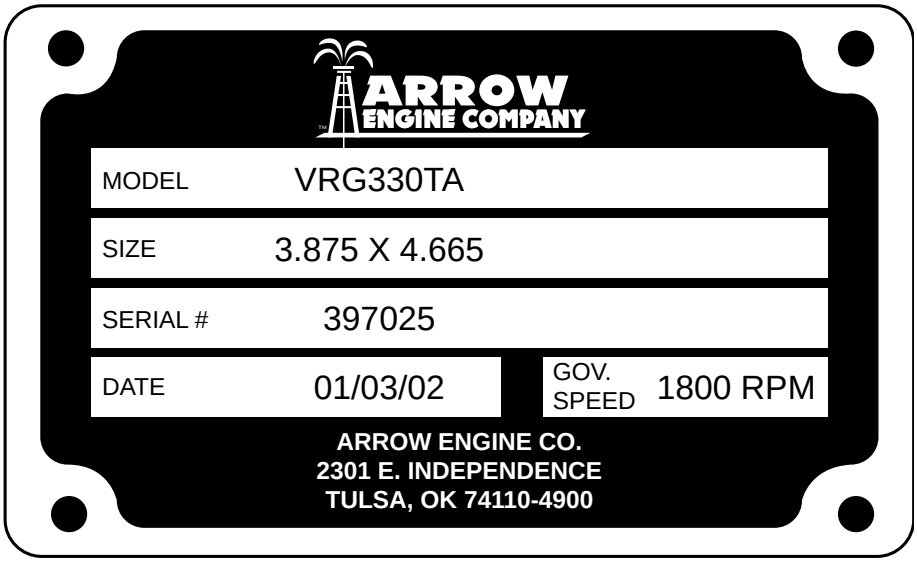
© JANUARY 2010

Customer Ordering Procedure

1. Genuine parts are available worldwide and must be ordered through your local distributor.

2. Part numbers in this catalog are for reference only, and should not be used for ordering parts. Your distributor will refer to your engine specification to make certain you receive the correct parts for your engine.

3. Always specify to your distributor the engine model designation and serial number, as found stamped on the engine name plate. Example below:



In the event the name plate is either lost or defaced, the engine serial number is also stamped on right rear side of the engine above the oil filter.

4. Always include the part number, when known, along with a description of the part. State the quantity of the part you wish to order. Do not use the word “complete” or designate the quantity by sets.

EXAMPLE: 162709A - Filter Element - (1) Ordered.

NOTE: Quantities listed in this manual are quantity per engine.

5. If a special part is needed, the engine application should also be stated.

6. Anticipate your parts requirements:

a) Order parts early in the day.

b) Keep a supply of normal maintenance parts in stock.

c) Obtain a parts stocking recommendation from your local distributor.

Parts Catalog Information

Parts Catalog Format

ILLUSTRATION NUMBER **002.00**

A B C

A) Group Number

B) For each different illustration in the same group this number advances by 1

C) For each repeated illustration this number advances by 1

Item No.
The first column lists the item numbers which correspond to the item numbers in the illustration.

Part Number and Description
The second column lists the part numbers. The last column lists the description of the part. Parts included in assemblies are preceded by one dot and parts included in subassemblies are preceded by two or three dots.

Engine Model Quantity
The engine model columns list the quantity of the part per engine except when parts are listed more than once in the catalog, the quantity per engine is the total of the quantities listed.

ENGINE MODEL QUANTITY

Item No.	Part Number	VRG220	VRG330	VRG330TA	Description (Category / Group)
	AA216102	1			ASSEMBLY
1	•A216102	1			•SUBASSEMBLY
2	••78283B	3	5	5	••PART OF SUBASSEMBLY
3	216000	1			INDIVIDUAL PART

Extent of Parts Catalog Coverage

This parts catalog contains only standard or selected option parts. Variations of these parts as well as other special parts are not included. Contact your local distributor for assistance in identifying parts not included in this catalog.

PARTS 1

Cylinder Head, Valves 3
Rocker Arms, Rocker Arm Cover 5
Pistons, Connecting Rods, Cylinder Sleeves 7
Crankshaft, Pulley & Flywheel 9
Oil Pan 11
Crankcase 13
Balancer 15
Thermostat Housing 17
Distributor Ignition 19
Magneto Ignition 21
Electronic Ignition 23
Coil Bracket 25
Camshaft, Lifter, Valve, Push Rod, Idler Gear 27
Turbocharger with Intercooler 29
Alternator 31
Belt Tightener 33
Turbocharger Oil Supply 35
Mechanical Governor & Linkage 37
68031 E Governor Assembly 39
Electronic Governor Assembly 41
Fan Bracket 43
Intake and Exhaust Manifold 45
Intake and Exhaust Manifold 47
Gear Cover 49
Oil Filter & Oil Cooler 51
Flywheel Housing, Starter 53
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Double Plate Clutch 57
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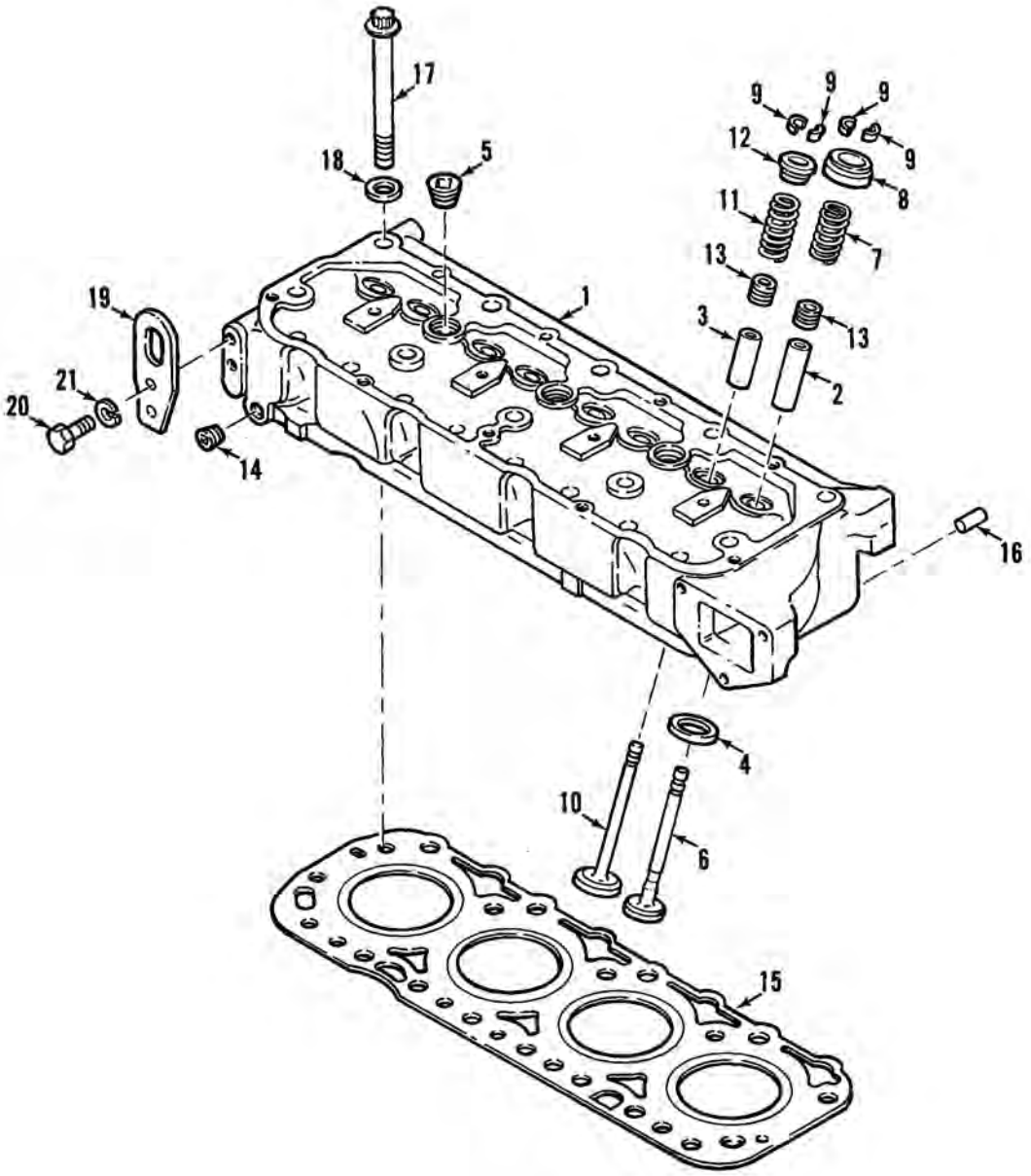
PARTS

VR220, VR330, VR330TA, VR330CF



CYLINDER HEAD, VALVES

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•••NO LONGER AVAILABLE

Cylinder Head, Valves
Group 2

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	CA216102	1				Head, Cylinder Assembly
	CA217102		1			
	CA217102B			1		
	AA217002A-CF				1	
1	•A216102	1				Cylinder Head
	•A217102		1			
	•A217102B			1		
	A217002A				1	
2	••224609A	4	6	6		Guide, Valve, Exhaust
	••216009				12	Guide, Valve, Exhaust & Intake
3	••224609D	4	6	6		Guide, Valve, Intake
4	••166469A	4	6			Insert, Valve Seat, Exhaust, 45°
	••166469C			6		Insert, Valve Seat, Exhaust
	••166469S		6	6		Insert, Valve Seat, Exhaust, 30°
	••166469B				6	Insert, Valve Seat, Exhaust
5	••78283B	3	5	5	5	Plug, Pipe, Countersunk Headless, 3/4”
6	•222536C	4	6			Valve, Exhaust
	•222536S			6		
	•216136				6	
7	•224135	4	6	6	6	Spring, Valve, Exhaust
8	•166369U			6		Insert, Valve Seat, Intake
	•166369S			6	6	
9	•163235	16	24	24	24	Taper, Valve Spring
10	•222436B	4	6			Valve, Intake
	•222436S			6		
	•216036				6	
11	•224135	4	6	6		Spring, Valve, Intake
	•224135A				6	
12	•163670	8	12	12	12	Retainer, Valve Spring
13	208712N	8	12	12	12	Seal, Valve Stem
14	26411	1	1	1	1	Plug, Pipe, Allen Head - Plated, 3/8”
15	216000A	1				Gasket, Cylinder Head
	217000A		1	1	1	
16	B9824	2	2	2	2	Pin, Dowel
17	28716	10	14	14	14	Screw, Cylinder Head
18	152879	10	14	14	14	Washer, Cylinder Head Screw
19	208579	1	1		1	Plate, Lifting Eye
	208579A			1		
20	29605	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 1”
21	1A-3/8	2	2	2	2	Washer, Lock, 3/8”
	208655CF				6	Sleeve, Spark Plug
	208655CFO				6	O-Ring
	208655CFW				6	Washer, Grafoil
	208655CFR				6	Retainer
	HT-100	1	1	1	1	Heat Tab, 235°F
	G-936-1		1			Valve Overhaul Kit (Items 2,3,4,6,10,13)
	G-936-1S			1		Valve Overhaul Kit (Items 2,3,4,6,10,13,22)
	G-936-2	1				Valve Overhaul Kit (Items 2,3,4,6,10,13)
	G-936-1CF				1	Overhaul Head Kit with Inset Seats

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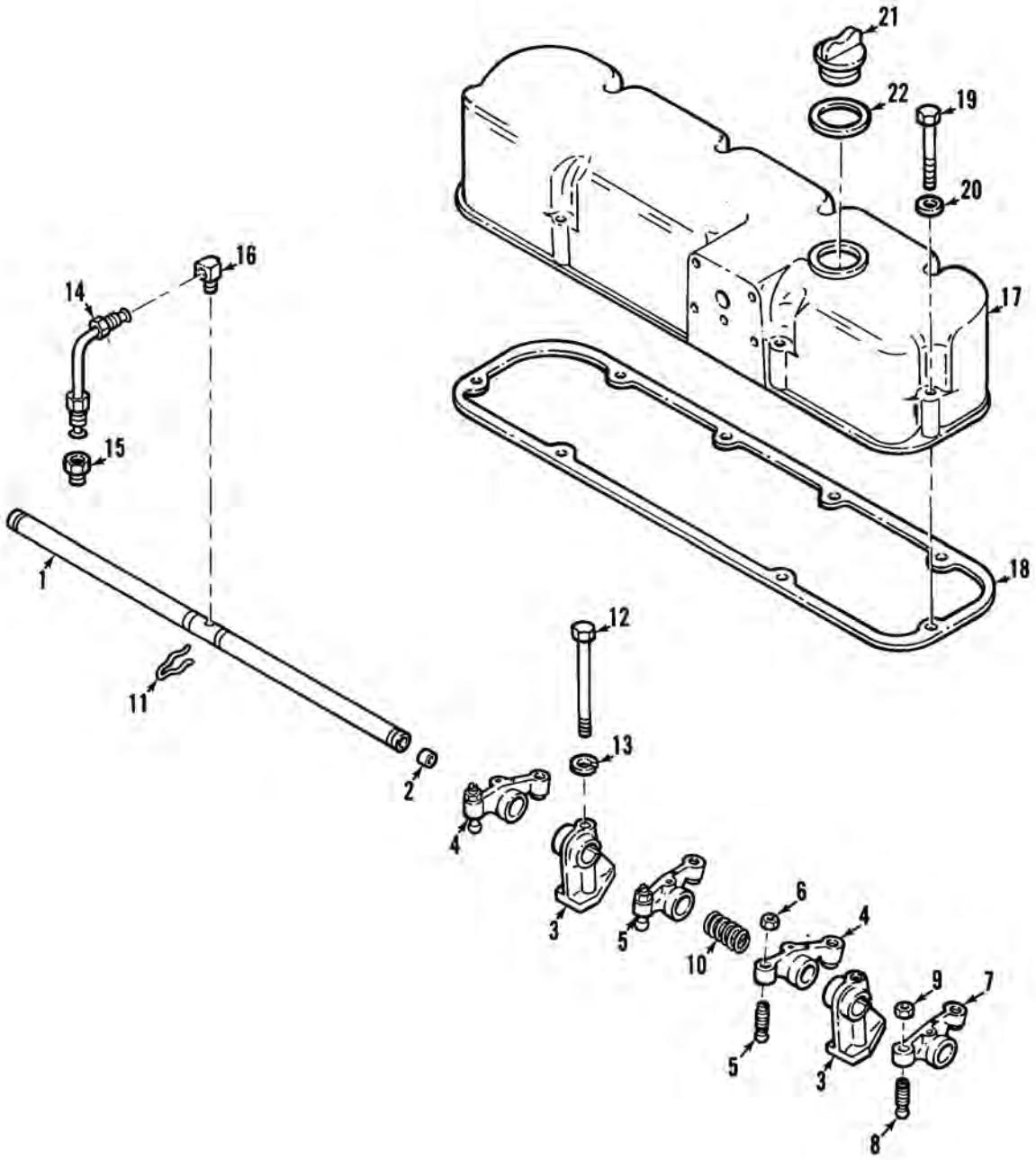

ROCKER ARMS, ROCKER ARM COVER

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Rocker Arms, Rocker Arm Cover

Groups 2, 39

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 2					
	DA216069	1				Shaft, Rocker Arm Assembly
	DA217069		1	1		
	CA217069				1	
1	•216069	1				Shaft, Rocker Arm
	•217069		1	1	1	
2	••B2857	2	2	2	2	Plug, Cup
3	•216068	4	6	6		Support, Rocker Arm
	•216068A				6	
4	•216066A	4				Arm, Rocker-R.H. (Intake # 1 & 2, Exhaust # 3 & 4)
	•216066A		6	6		Arm, Rocker-R.H. (Intake # 1, 2 & 3, Exhaust # 4, 5 & 6)
	•A223267				6	Arm, Rocker - Intake
5	••120860	4	6	6		Screw, Adjusting
6	••21195	4	6	6	6	Nut, Thin Hex, 3/8”-24
7	•216065A	4				Arm, Rocker-L.H. (Exhaust # 1 & 2, Intake # 3 & 4)
	•216065A		6	6		Arm, Rocker-L.H. (Exhaust # 1, 2 & 3, Intake # 4, 5 & 6)
	•A223367				6	Arm, Rocker - Exhaust
8	••120860	4	6	6	6	Screw, Adjusting
9	••21195	4	6	6	6	Nut, Thin Hex, 3/8” - 24
10	•73888	2	4	4	4	Spring
11	•76898	4	4	4	4	Cotter, Rocker Arm Shaft
12	7A-3/816X31/2	4	6	6	6	Screw, Cap, Hex Head, 3/8” - 16 x 3 1/2”
13	1A-3/8	4	6	6	6	Washer, Lock, 3/8”
14	A166009F	1	1	1	1	Tube, Oil
15	73017A	1	1	1	1	Connector, Inverted
16	73018A	1	1	1	1	Elbow, Inverted
	GROUP 39					
17	•••216139	1				Cover, Rocker Arm (Less Oil Filler Provision)
	217139		1	1		
	216139A	1				Cover, Rocker Arm (With Oil Filler Provision)
	•••217039A				1	
18	208617	1				Gasket, Rocker Arm Cover
	208615		1	1	1	
19	21291	8	12	12	12	Screw, Cap, Hex Head, 1/4” - 20 x 2”
20	1N-1/4	8	12	12	12	Washer, Plain, 1/4”
21	B4296	1	1	1	1	Cap, Oil Filter
22	176412	1	1	1	1	Gasket, Oil Filler Cap

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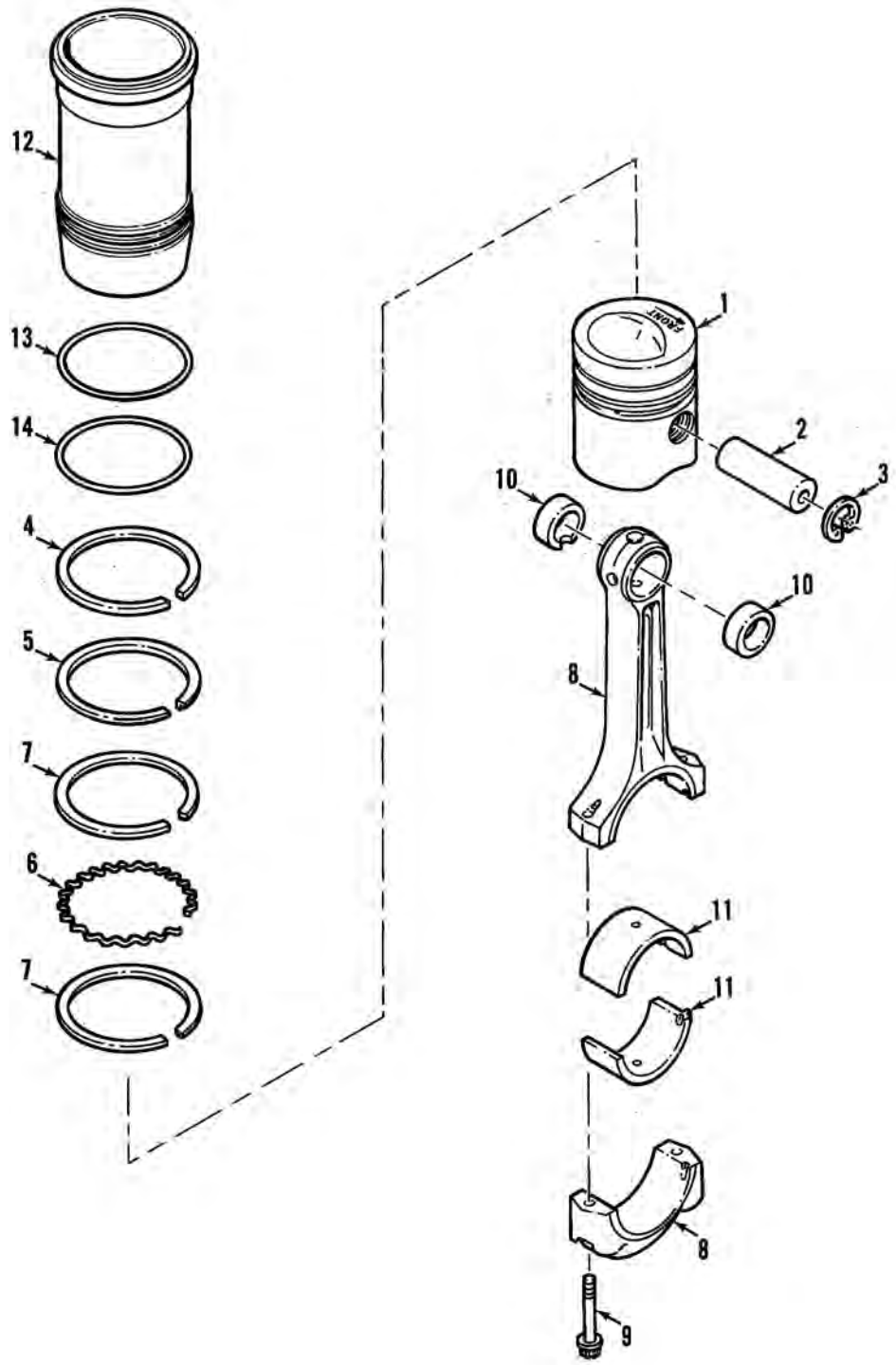

PISTONS, CONNECTING RODS, CYLINDER SLEEVES

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Pistons, Connecting Rods, Cylinder Sleeves

Groups 4, 7, 30

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 4					
1	216104A	4	6	6		Piston (8:1)
	216104HC	4	6	6		Piston (10:1)
	216104CF				6	Piston, Crossflow (8:1)
2	221006A	4	6	6	6	Pin, Piston
3	44999	8	12	12	12	Retainer, Piston Pin
4	223305B	4	6	6	6	Ring, Piston - Compression (Top Groove)
	223305C	4	6	6	6	Ring, Piston - Compression (Top Groove) Hastings
5	223605M	4	6	6	6	Ring, Piston - Compression
	223605N	4	6	6	6	Ring, Piston - Compression, Hastings
6	221705	4	6	6	6	Spacer, Oil Ring Rails
7	221805	8	12	12	12	Rail, Oil Ring
	GROUP 7					
8	A216007	4	6	6	6	Rod, Connecting - Assembly
9	•208447A	8	12	12	12	Bolt, Connecting Rod
10	•216008	8	12	12	12	Bushing, Piston Pin
	•216008A	8	12	12	12	Bushing, Piston Pin, Aluminum
11	216010A	4	6	6	6	Bearing, Connecting Rod Pair
	HW216010A3	4	6	6	6	Bearing, Connecting Rod Pair, .030
	216010A2	4	6	6	6	Bearing, Connecting Rod Pair, .020
	HW216010A1	4	6	6	6	Bearing, Connecting Rod Pair, .010
	GROUP 30					
12	216030C	4	6	6	6	Sleeve, Cylinder
13	208464B	8	12	12	12	Ring, Packing - Cylinder Sleeve (Upper Groove - Black)
14	208465A	4	6	6	6	Ring, Packing - Cylinder Sleeve (Lower Groove - Red)
	KITS					
	907-185	4	6	6	6	Single Piston Ring Kit (8:1) (Includes Items 4-7)
	932-262	4	6	6		Single Cylinder Sleeve Kit (8:1) (Includes Items 1-7, 12-14)
	932-262-CF				6	Single Cylinder Sleeve Kit (8:1 Crossflow) (Includes Items 1-7, 12-14)

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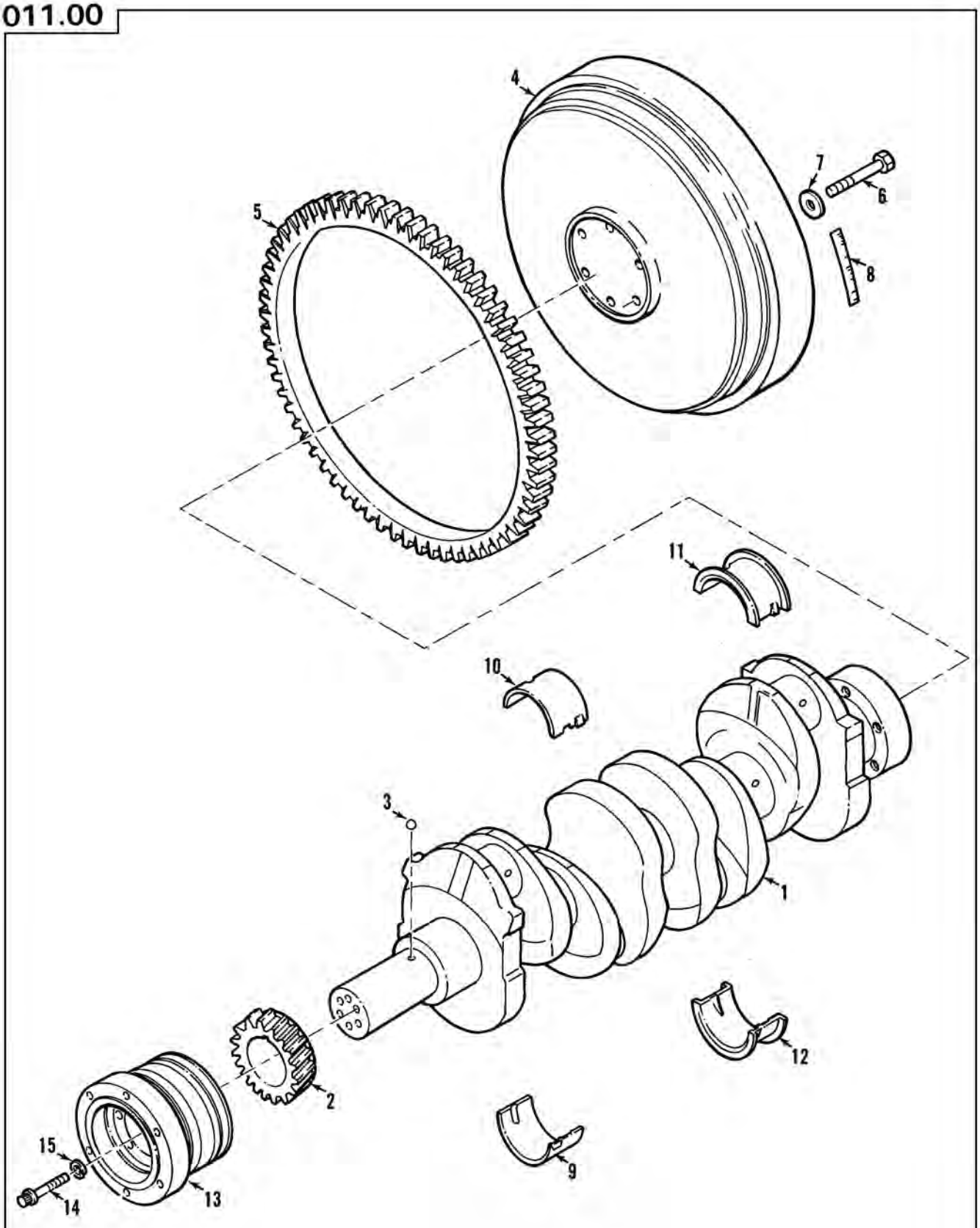


CRANKSHAFT, PULLEY, FLYWHEEL

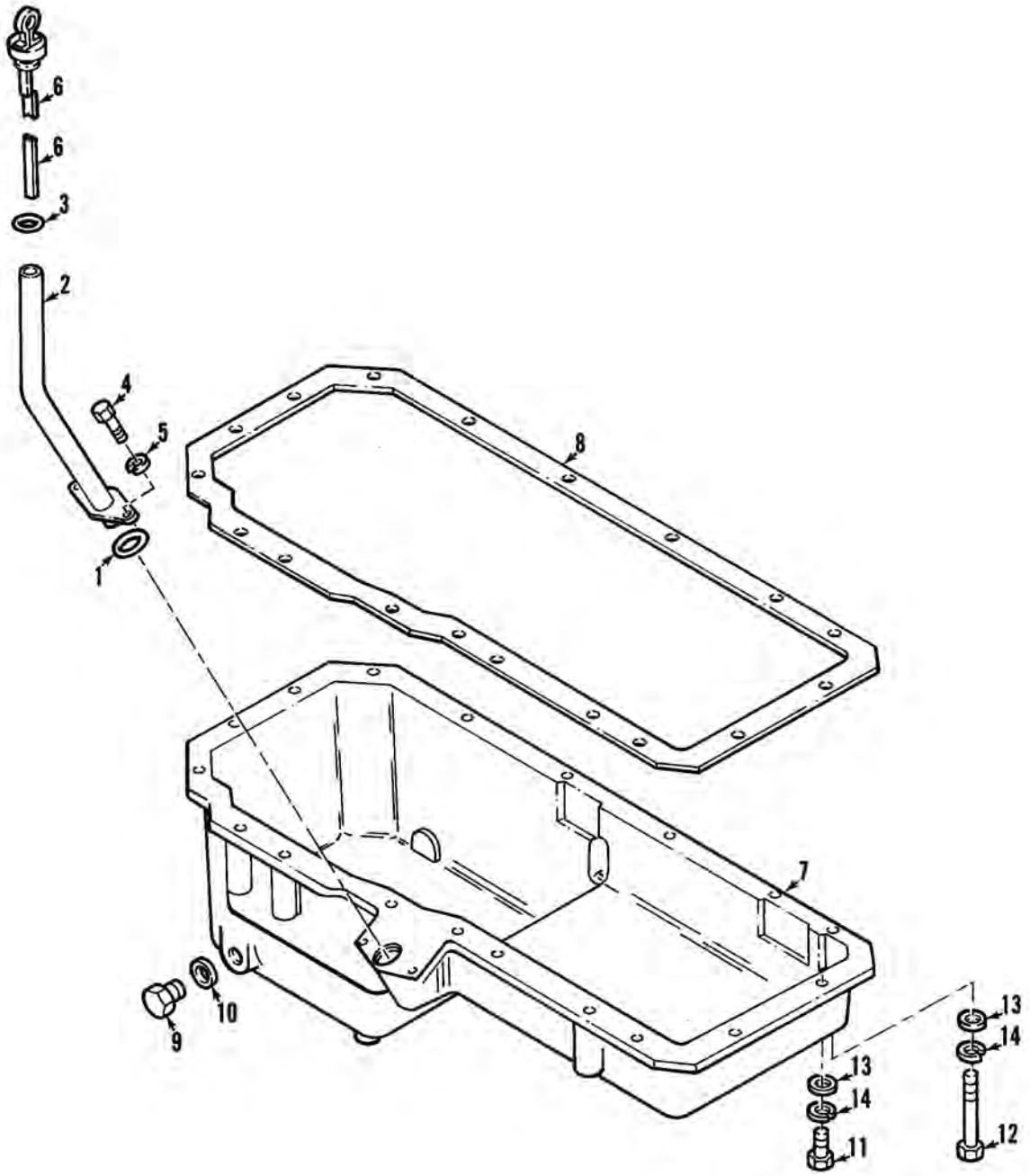
•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Crankshaft, Pulley & Flywheel

Groups 11, 13, 20 & 95

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 11					
	A216011	1				Crankshaft Assembly (Not Sold Separately)
	A217011		1	1	1	
1	•216011	1				Crankshaft, Less Gear
	•217011		1	1	1	
2	•216012	1	1	1	1	Gear, Crankshaft
3	•207988	1	1	1	1	Ball, Crankshaft Gear Retaining
	GROUP 13					
	A216013	1	1	1	1	Flywheel Assembly
4	•216013	1	1	1	1	Flywheel
5	•190066	1	1	1	1	Gear, Ring - Flywheel
6	28642	6	6	6	6	Screw, Cap, Hex Head - Grade 8, 7/16” - 20 x 2”
7	810245	6	6	6	6	Washer, Plain, 7/16”
8	208623H	1	1	1	1	Tape, Timing
	74013A	1	1	1	1	Stub Shaft
	GROUP 20					
9	216022A	4	6	6	6	Bearing, Main, Lower Only
10	216022	4	6	6	6	Bearing, Main, Upper Only
11	216018	1	1	1	1	Bearing, Main - Thrust - Upper Only
	2160182	1	1	1	1	Bearing, Main - Thrust - Upper Only, .020
12	216018A	1	1	1	1	Bearing, Main - Thrust - Lower Only
	216018A2	1	1	1	1	Bearing, Main - Thrust - Lower Only, .020
	GROUP 95					
13	216095B	1	1	1	1	Pulley, Crankshaft (With Bracket Mounted Fan)
	216295A	1	1	1	1	Pulley, Crankshaft (With Water Pump Mounted Fan)
	216295A-2	1	1	1	1	3 Groove Pulley
	216295A-3	1	1	1	1	Pulley with Holes Drilled for CD-Ignition
	216195					Pulley Extension, 5” Diameter, 2 Groove
14	28643	6	6	6	6	Screw, Cap, Ferry Head, 3/8” - 24 x 1 3/8”
15	1A-3/8	6	6	6	6	Washer, Lock, 3/8”
	KITS					
	911-209	1				Crankshaft & Crankshaft Bearing Kit (Includes Items 1-3, 9-12 and Connecting Rod Bearings)
	911-216		1	1	1	
	G-918-307	1				Main Bearing Kit - Standard (Includes Items 9-12)
	G-918-308		1	1	1	
	HW918309	1				Main Bearing Kit - .010” Undersize (Includes Items 9-12)
	HW918310		1	1	1	
	G-918-311	1				Main Bearing Kit - .020” Undersize (Includes Items 9-12)
	G-918-312		1	1	1	
16	992111	1	1	1	1	Sleeve Front
17	994511	1	1	1	1	Sleeve Rear

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE



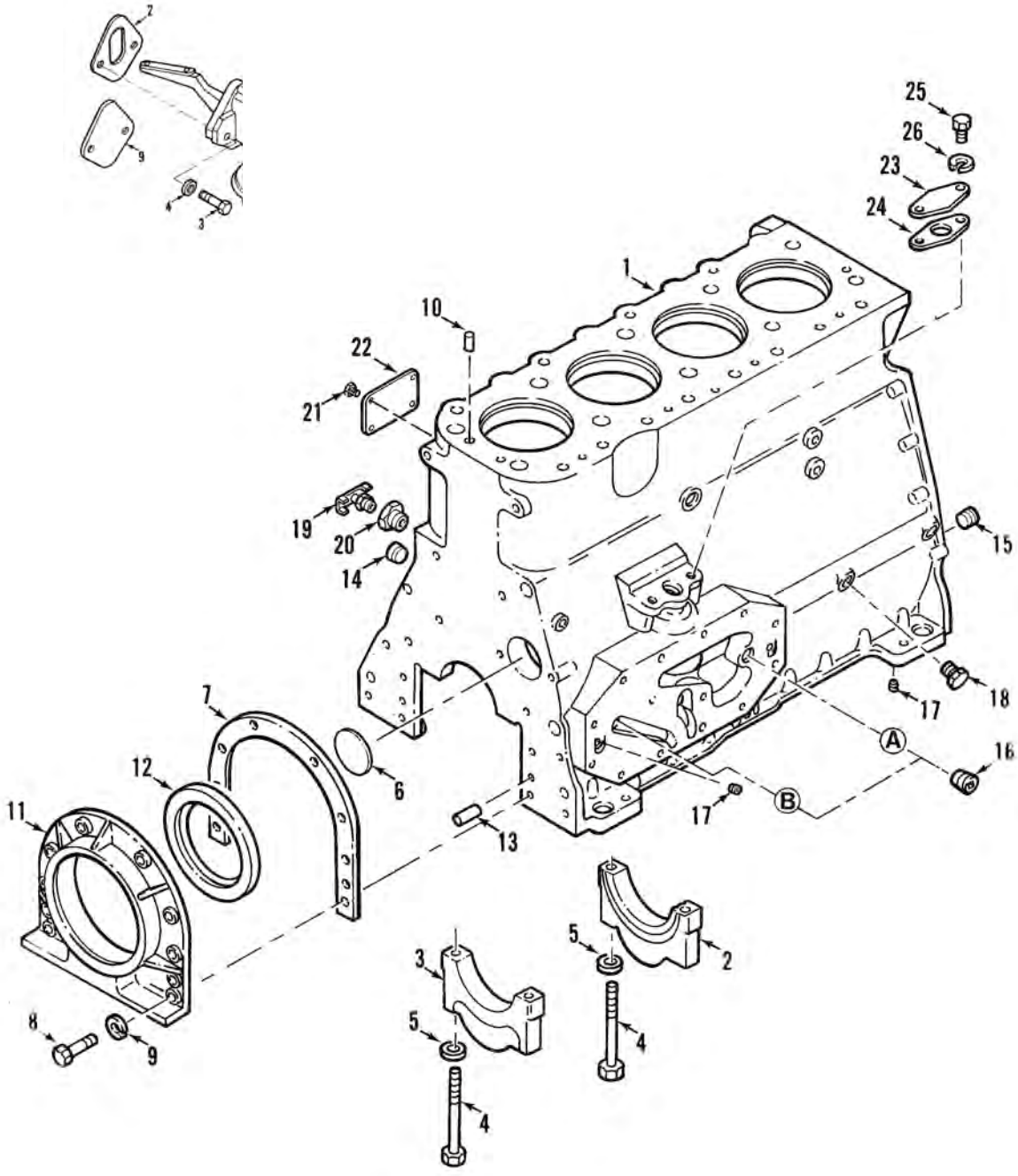
OIL PAN

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Oil Pan
Groups 3,14

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 3					
1	118013M	1	1	1	1	O-Ring
2	A208481A	1	1	1	1	Tube, Oil Level Dipstick (With 199178 Series Dipstick)
	176535B	1				Tube, Oil Level Dipstick (With 208602 Series Dipstick)
3	157497X	1	1	1	1	O-Ring
4	7A-5/1618X7/8	2	2	2	2	Screw, Cap, Hex Head, 5/16”-18x7/8”
5	1A-5/16	2	2	2	2	Washer, Lock, 5/16”
6	199178C	1				Dipstick, Oil Level (With 216114 Oil Pan)
	199178D	1				Dipstick, Oil Level (With 216014 Oil Pan)
	199178F		1	1		Dipstick, Oil Level (With 217014 Oil Pan)
	199178G	1				Dipstick, Oil Level (With 216214, 216214A Oil Pan)
	199178H		1	1	1	Dipstick, Oil Level (With 21701HC Oil Pan)
	208602	1				Dipstick, Oil Level (With 216114A Oil Pan)
	208602A	1				Dipstick, Oil Level (With 217014A Oil Pan)
	GROUP 14					
7	216114	1				Pan, Oil (Front Sump - R.H. Oil Level Dipstick)
	216014	1				Pan, Oil (Deep Rear Sump - R.H. Oil Level Dipstick)
	217014B		1	1		Pan, Oil (Deep Rear Sump - R.H. Oil Level Dipstick)
	21701HC		1	1	1	Pan, Oil (High Capacity)
8	208626	1				Gasket, Oil Pan
	208626A		1	1	1	
9	76909	1	1	1	1	Plug, Drain
10	B175	1	1	1	1	Gasket, Drain Plug
11	7A-8/1618X1	11	19	19	19	Screw, Cap, Hex Head, 5/16” - 18 x 1”
12	26125	7	3	3	3	Screw, Cap, Hex Head, 5/16” - 18 x 3 3/4”
13	B277	18	22	22	22	Washer, Plain, 5/16”
14	1A-5/16	18	22	22	22	Washer, Lock, 5/16”
	KITS					
	5020-K	1	1	1	1	Oil Level Kit (Less Regulator)
	5020	1	1	1	1	Oil Level Kit (With Regulator)

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

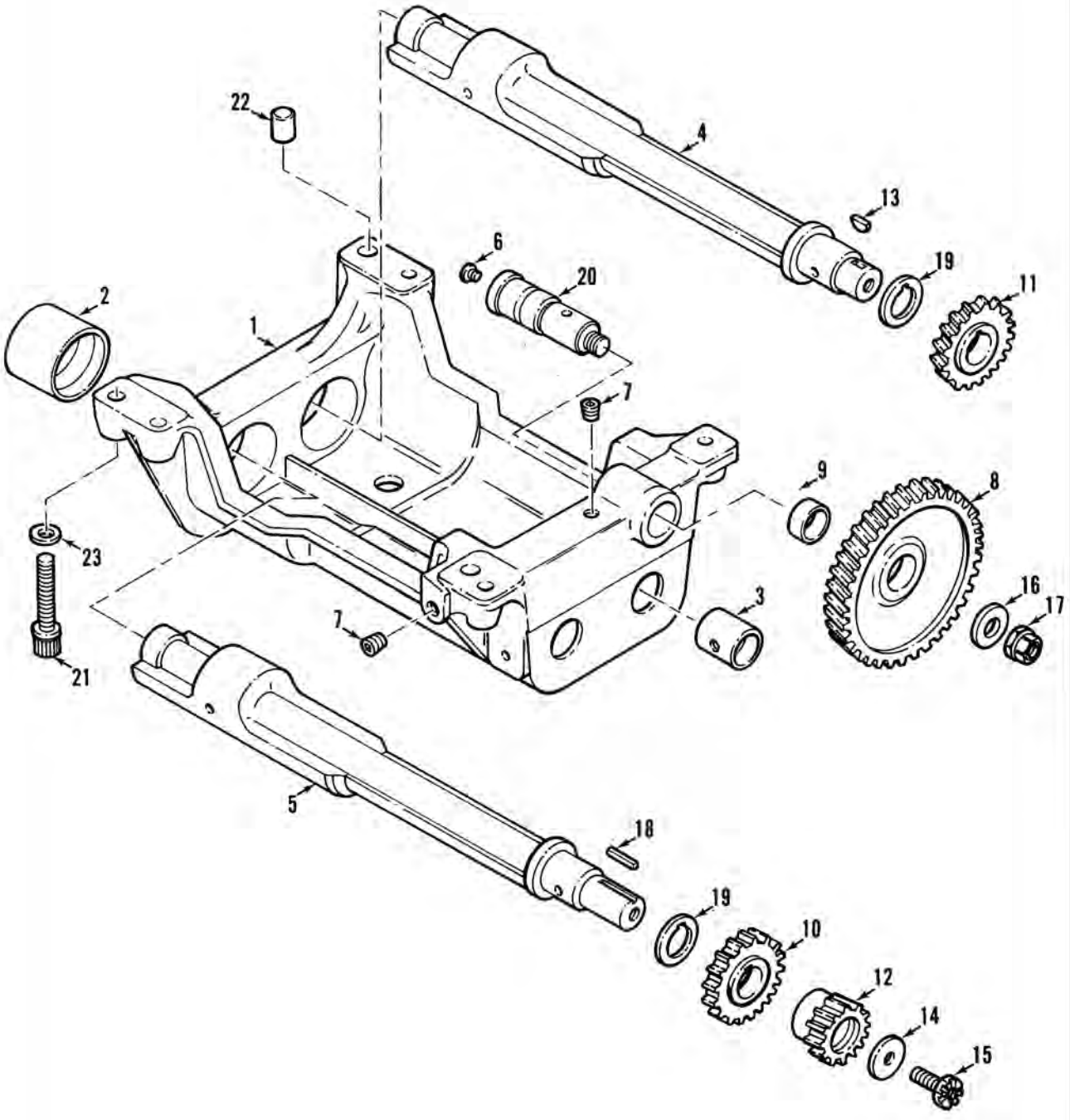


CRANKCASE

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Crankcase
Groups 16, 19, 20, 75

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 20					
1	A216020A	1				Crankcase Assembly (Includes Camshaft Bushings)
	C217020		1	1	1	
2	•216049A	1	1	1	1	Cap, Main Bearing - Thrust (Serviced Only as Semi-finished)
3	•216046A	4	6	6	6	Cap, Main Bearing (Serviced Only as Semi-Finished)
4	•151796A	10	14	14	14	Screw, Main Bearing Cap
5	•152879	10	14	14	14	Washer, Plain, 5/8”
6	•80609	1	1	1	1	Plug, Expansion
7	208448	1	1	1	1	Gasket, Rear Oil Seal Retainer
8	7A-5/1618X3/4	8	8	8	8	Screw, Cap, Hex Head, 5/16” - 18 x 3/4”
9	1A-5/16	8	8	8	8	Washer, Lock, 5/16”
10	B3568	2	2	2	2	Pin, Dowel
11	A216090	1	1	1	1	Retainer, Rear Oil Seal - Assembly
12	•208458T	1	1	1	1	Seal, Oil - Rear
	208458TI	1	1	1	1	Tool, Rear Seal Installation
13	B565	2	2	2	2	Pin, Dowel
14	78283J	3	2	2	2	Plug, Pipe, Countersunk Headless - Plated, 1/2”
15	26411	2	4	4	4	Plug, Pipe, Allen Head - Plated, 3/8” (Less Oil Cooler)
16	26411	1	1	1	1	Plug, Pipe, Allen Head - Plated, 3/8” (With Oil Cooler)
17	Y18802	4	3	3	3	Plug, Pipe, Allen Head, 1/8” (Less Balancer)
	Y18802	3				Plug, Pipe, Allen Head, 1/8” (With Balancer)
18	26743	4	5	5	5	Plug, Pipe, Hex Head, 1/8”
19	76400	1	1	1	1	Cock, Drain
20	78212C	1	1	1	1	Bushing, Reducing, 1/2” to 1/4”
	HT-100	1	1	1	1	Heat Tab, 235°
	GROUP 16					
21	B557A	4	4	4	4	Pin, Name Plate
22	20768	1	1	1	1	Plate, Name
	GROUP 75					
23	208763	1	1	1	1	Plate, Cover (Less Distributor)
24	208762	1	1	1	1	Gasket, Cover Plate (Less Distributor)
25	7A-3/816X7/8	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 7/8” (Less Distributor)
26	1A-3/8	2	2	2	2	Washer, Lock, 3/8” Less Distributor
	GROUP 19					
27	73842C	1	1	1	1	Gasket, Fuel Pump
28	7A-5/1618X7/8	2	2	2	2	Screw, Cap, Hex Head, 5/16” - 18 x 7/8”
29	B2135	2	2	2	2	Washer, Plain - Copper, 5/16”
30	73954C	1	1	1	1	Cover
	KITS					
	975-268	1				Short Block, Compression Ratio 8:1
	975-277		1	1		

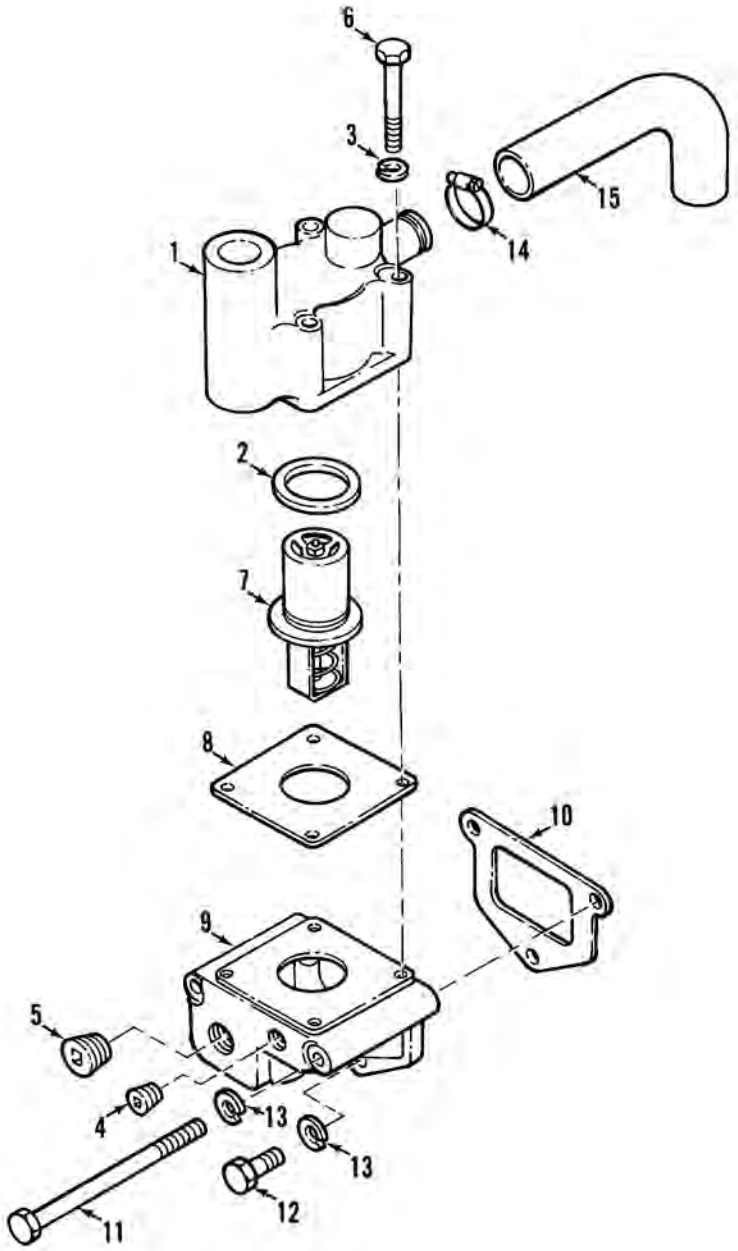


BALANCER

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Balancer
Group 20

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	F208398	1				Cradle, Balancer - Assembly
	•G208398	1				
1	••208398	1				Cradle, Balancer
2	••208399A	2				Bushing, Rear
3	••208400A	2				Bushing, Front
4	•208410F	1				Shaft, Balancer
5	•208410G	1				Shaft, Balancer
6	•26731	1				Plug, Pipe, Allen Head, 1/16”
7	•Y18802	2				Plug, Pipe, Allen Head, 1/8”
	•A208406	1				Gear, Balancer Idler - Assembly
8	••208406	1				Gear, Balancer Idler
9	••208405	1				Bushing, Idler Gear
10	•208403D	1				Gear, Balancer - Driver
11	•208402	1				Gear, Balancer - Driver
12	•208403E	1				Gear, Balancer - Driver
13	•21001	1				Key, Woodruff, No. 2
14	•169522A	2				Washer, Plain
15	•28461	2				Screw, Cap, Place Type, 3/8” - 24 x 3/4”
16	•169420C	1				Washer, Thrust
17	•26729	1				Nut, Thin Hex - Flex Loc, 1.2” - 20
18	•209277	1				Key, Square, 1/8” x 1/8” x 1”
19	•169680C	2				Shim, Balancer Shaft - Assembly (Thickness of .0015, .003 and .005 Brass Shims laminated together)
20	•208411	1				Spindle, Idler
21	28669	6				Screw, cap, Ferry Head, 3/8” - 16 x 1 3/4”
22	169529	2				Pin, Dowel - Hollow
23	B6717	6				Washer, Plain, 3/8”
24	F208398RP					Balancer Repair Kit



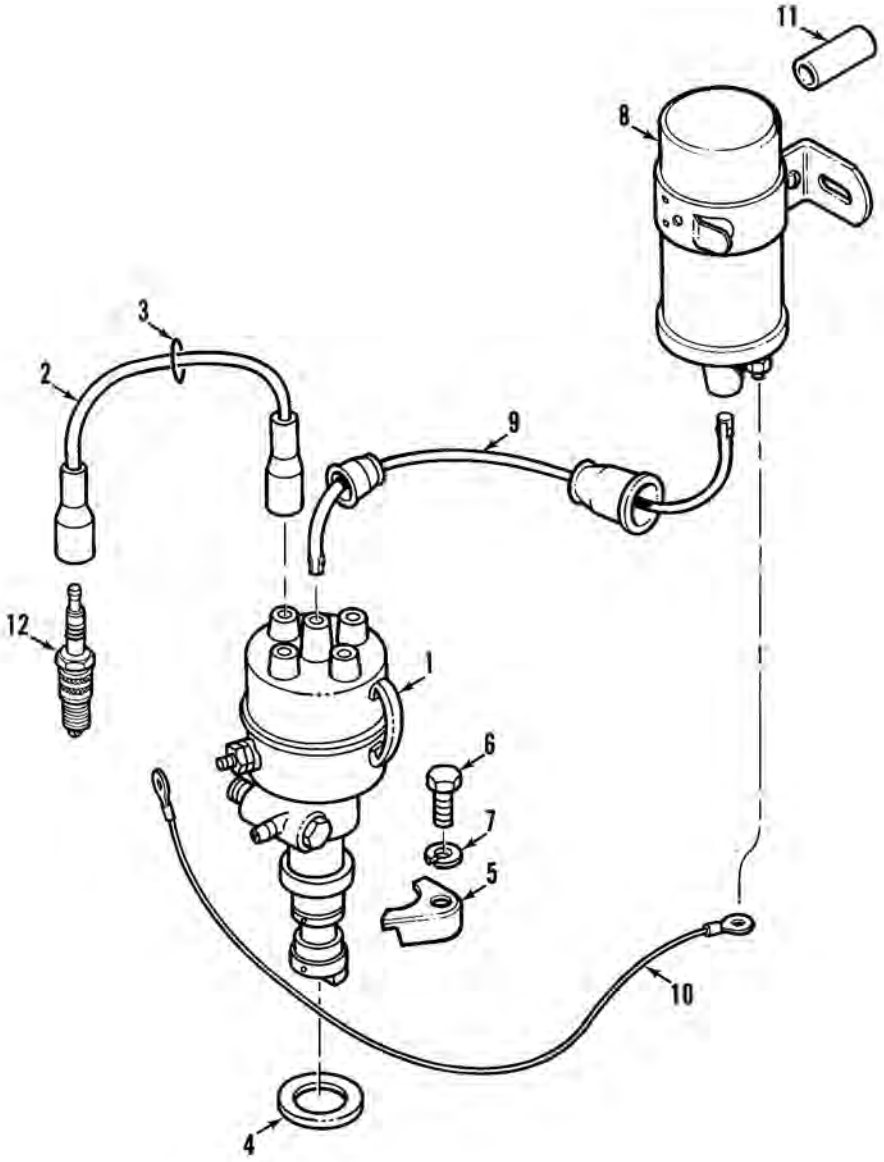
THERMOSTAT HOUSING

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Thermostat Housing
Group 21

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	AA216078	1	1	1	1	Housing, Thermostat - Assembly
1	••216078	1	1	1	1	Housing, Thermostat
2	••199175A	1	1	1	1	Seal, Thermostat
3	•1A-5/16	4	4	4	4	Washer, Lock, 5/16”
4	•21951	1	1	1	1	Plug, Pipe, Countersunk Headless, 3/8”
5	•78283A	1	1	1	1	Plug, Pipe, Countersunk Headless, 1/2”
6	•21324	4	4	4	4	Screw, Cap, Hex Head, 5/16” - 18 x 2 3/4”
7	•208622	1	1	1	1	Thermostat 175°F (79°C)
	•208622A	1	1	1	1	Thermostat 190°F (88°C) (Optional)
8	•208593	1	1	1	1	Gasket, Thermostat Housing
9	•216077	1	1	1	1	Adaptor, Thermostat Housing
10	208592	1	1	1	1	Gasket, Water Outlet
11	21374	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 4 1/4”
12	7A-3/816X1	1	1	1	1	Screw, Cap, Hex Head, 3/8” 16 x 1”
13	1A-3/8	3	3	3	3	Washer, Lock, 3/8”
14	41236G	2	2	2	2	Clamp, Hose
15	208576A	1	1	1	1	Hose, Bypass
	26411	1	1	1	1	Socket, Plug, Pipe, HD 3/8”

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE



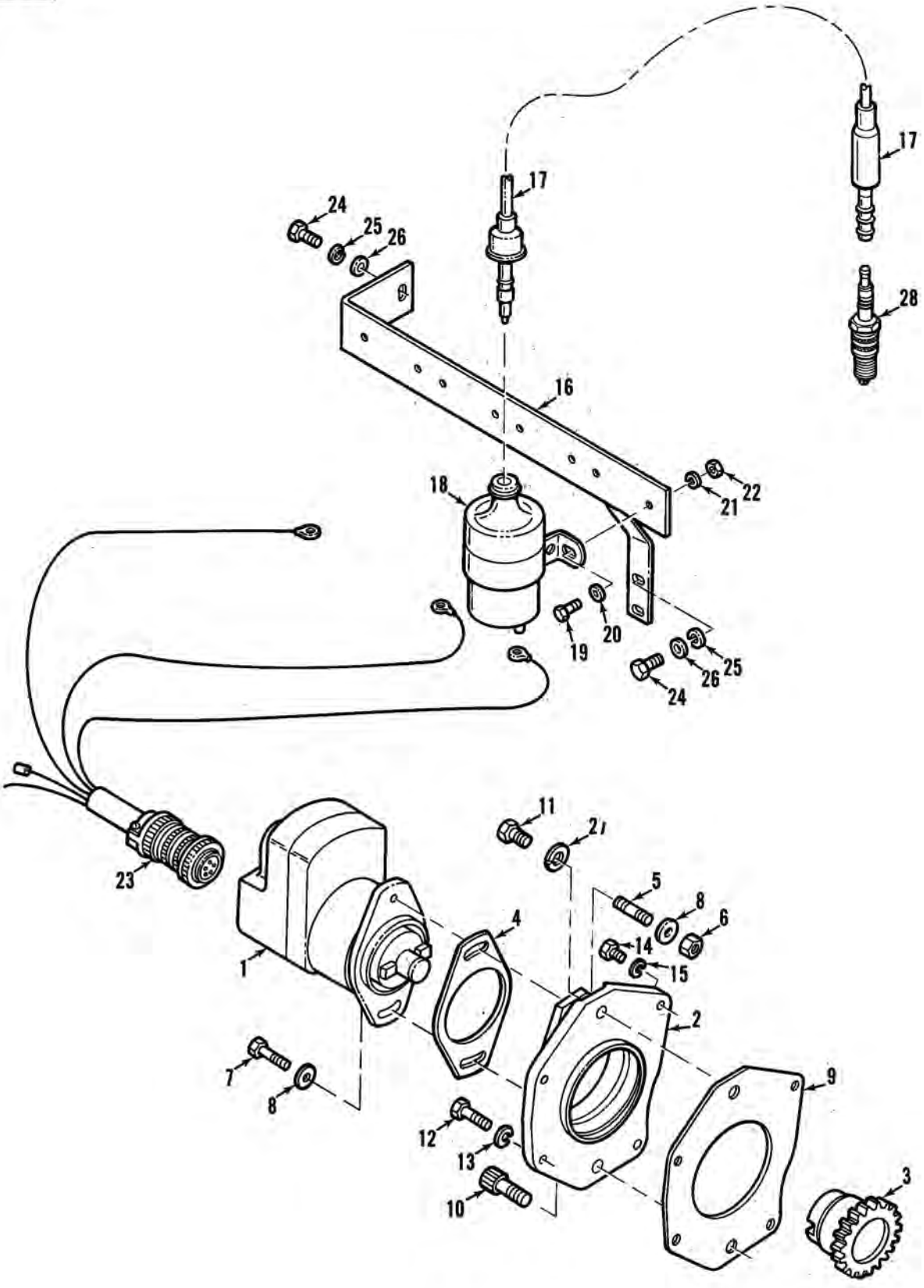
DISTRIBUTOR IGNITION

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Distributor Ignition
Groups 22, 26

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 22					
1	A69752A	1				Distributor Assembly
	A69498E		1	1	1	
	•69752A	1				Distributor
	•69498E		1	1	1	
	••491960	1	1	1	1	Point Set
	••491961	1	1	1	1	Condenser
	••485042	1				Cap
	••485036		1	1	1	
	••485037	1	1	1	1	Rotor
2	•163504B	1				Cable, Ignition (Cylinder 1)
	•163504B		2	2	2	Cable, Ignition (Cylinders 1 & 6)
	•163505B	2	2	2	2	Cable, Ignition (Cylinders 3 & 4)
	•163506B	1				Cable, Ignition (Cylinder 2)
	•163506B		2	2	2	Cable, Ignition (Cylinders 2 & 5)
	•69462A-CF				1	Cable, Spark Plug, Set of 6
3	•B7610	2	2	2	2	Ring, Rubber
4	116292	1	1	1	1	Gasket, Distributor
5	169671C	2	2	2	2	Clamp, Distributor
6	21350	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 1 1/8”
7	1A-3/8	2	2	2	2	Washer, Lock, 3/8”
8	50192B	1	1	1	1	Coil
9	065681	1	1	1	1	Cable, Distributor/Coil
10	0116225	1	1	1	1	Wire, Distributor/Coil
11	158478A	1	1	1	1	Spacer
	GROUP 26					
12	69462	4	6	6		Spark Plug
	69462-CF				6	

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE



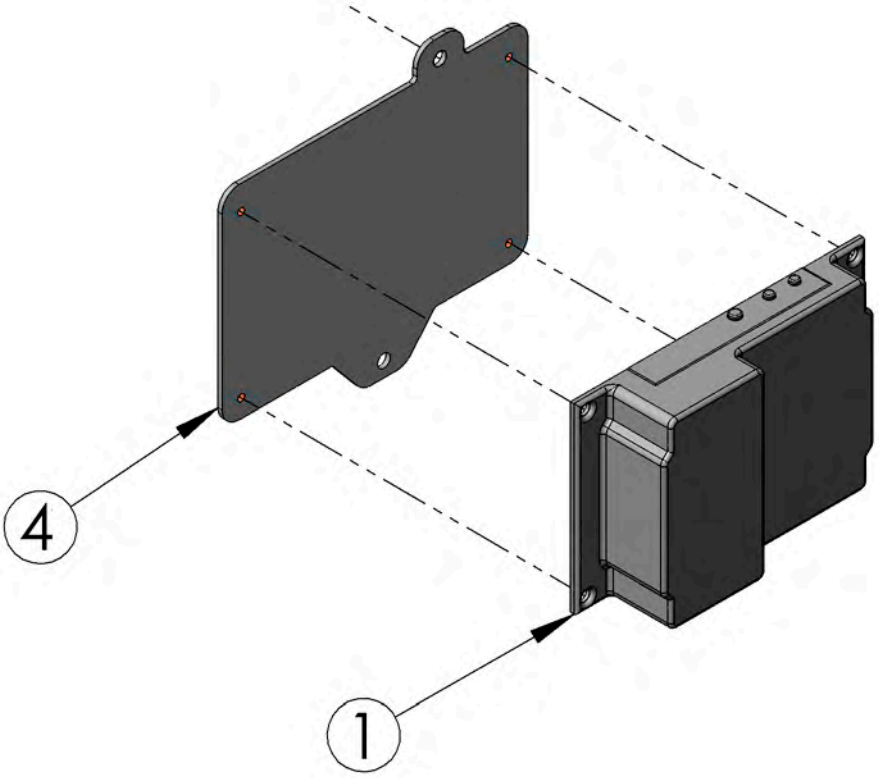
MAGNETO IGNITION

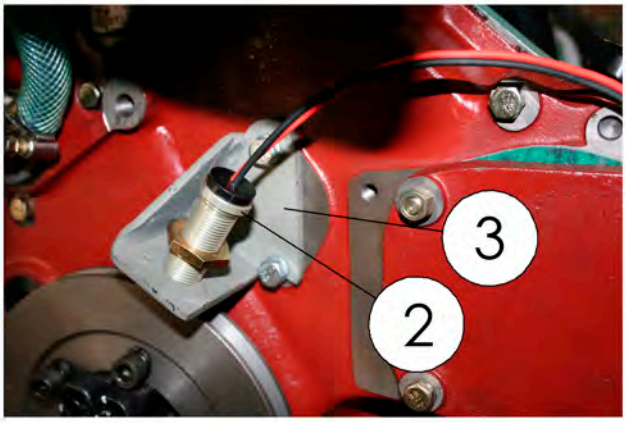
•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Magneto Ignition

Groups 22, 26

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 22					
	A209729B	1				Magneto Assembly - Altronic V
	A209729C		1		1	
	A209729H			1		
1	•209729B	1				Magneto
	•209729C		1		1	
	•209729H			1		
2	•216067	1				Adaptor, Magneto Drive
	•217067		1	1	1	
3	•216019	1				Gear, Magneto Drive
	•217019		1	1	1	
4	•73904	1	1	1	1	Gasket, Magneto
5	•209237A	1	1	1	1	Stud
6	•29D-3/816	1	1	1	1	Nut, Thin Hex, 3/8” - 16
7	•21350	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16 x 1 1/8”
8	•1N-3/8	2	2	2	2	Washer, Plain, 3/8”
9	208643	1	1	1	1	Gasket, Adaptor Plate
10	7A-1/213X11/4	1	1	1	1	Screw, Cap, Hex Head, 1/2” - 13 x 1 1/4”
11	7A-1/213X3/4	1	1	1	1	Screw, Cap, Hex Head, 1/2” - 13 x 3/4”
12	7A-5/1618X11/4	3	3	3	3	Screw, Cap, Hex Head, 5/16” - 18 x 1 1/4”
13	1A-5/16	3	3	3	3	Washer, Lock, 5/16”
14	7A-5/1618X3/4	1	1	1	1	Screw, Cap, Hex Head, 5/16” - 18 x 3/4”
15	B2135	1	1	1	1	Washer, Plain - Copper, 5/16”
	A208391J	1				Bracket, Coil - Assembly
	A208391K		1		1	
	C208391G			1		
16	•208391J	1				Bracket, Coil
	•208391K		1	1	1	
17	•163505B	4	6	6	6	Cable, Spark Plug
18	•69694	4	6	6	6	Coil, Ignition
19	•7A-1/420X3/4	8	12	12	12	Screw, Cap, Hex Head, 1/4” - 20 x 3/4”
20	•1N-1/4	8	12	12	12	Washer, Plain, 1/4”
21	•1A-1/4	8	12	12	12	Washer, Lock, 1/4”
22	•29A-1/420	8	12	12	12	Nut, Hex, 1/4” - 20
23	•C209728	1				Harness, Magneto
	•A209728		1	1	1	
24	28280	3	3	3	3	Screw, Cap, Hex Head - Grade 8, 3/8” - 16 x 7/8”
25	1N-3/8	3	3	3	3	Washer, Plain, 3/8”
26	1A-3/8	3	3	3	3	Washer, Lock, 3/8”
27	1A-1/2	1		1		Washer, Lock, 1/2”
	GROUP 26					
28	69462	4	6	6		Spark Plug
	69462-CF				6	
	CPM-2					Spark Plug, Shielded





•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Electronic Ignition
Groups 22, 26

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 22					
	3344-3CD					CD1 Ignition Assembly (Includes Bracket Assembly)
1	7910106					CD1 Ignition Unit
	26237				1	Screw, Hex Head 5/16” - 18 x 3 1/2”
	162557A				3	Splice, Closed End
	AES-66				4	Eyelet, Small Hole
2	7910151				1	Magnetic Pickup
	B2135				1	Washer
	7A-3/816x5/8				1	Capscrew, Hex Head
	7A-5/1618x11/4				3	Capscrew, Hex Head
	7A-5/1618x3/4				1	Capscrew, Hex Head
	1A-1/2				1	Lockwasher, Plated
	1A-1/4				4	Lockwasher, Plated
	1A-3/8				6	Lockwasher, Plated
	1A-5/16				2	Lockwasher, Plated
	1B-5/16				2	Washer, Flat, Standard
	1N-1/4				4	Washer, Flat, SAE Plated
	1N-3/8				2	Washer, Flat, SAE Plated
	1N-5/16				2	Washer, Flat, SAE Plated
	21950				1	Washer, Brass, 5/16”
	26461				1	Screw, Skt. Head, 1/2” - 13 x 1 1/4” Zinc Plated
	29A-3/8 16				1	Nut, Hex, Finished
	7A-1/420x11/4				1	Capscrew, Hex Head
	7A-1/420x1				4	Capscrew, Hex Head
	7A-3/816x1				1	Capscrew, Hex Head
	7A-3/816x11/2				1	Capscrew, Hex Head
	7A-3/816x23/4				1	Capscrew, Hex Head
	7A-3/816x3/4				2	Capscrew, Hex Head
	73904				1	Gasket, Magneto
	169013H				1	Clip, .31 Diameter x .38 Scr.
	169013M				3	Clip, .44 Diameter x .38 Scr.
	208643				1	Gasket, Adaptor Plate
	217067CD-S				1	Spacer, Ignition Bracket
	217067				1	Adaptor, Magneto Drive
3	208512MP				1	Bracket, Pickup, Primed
4	217067CD				1	Bracket, Ignition, Primed

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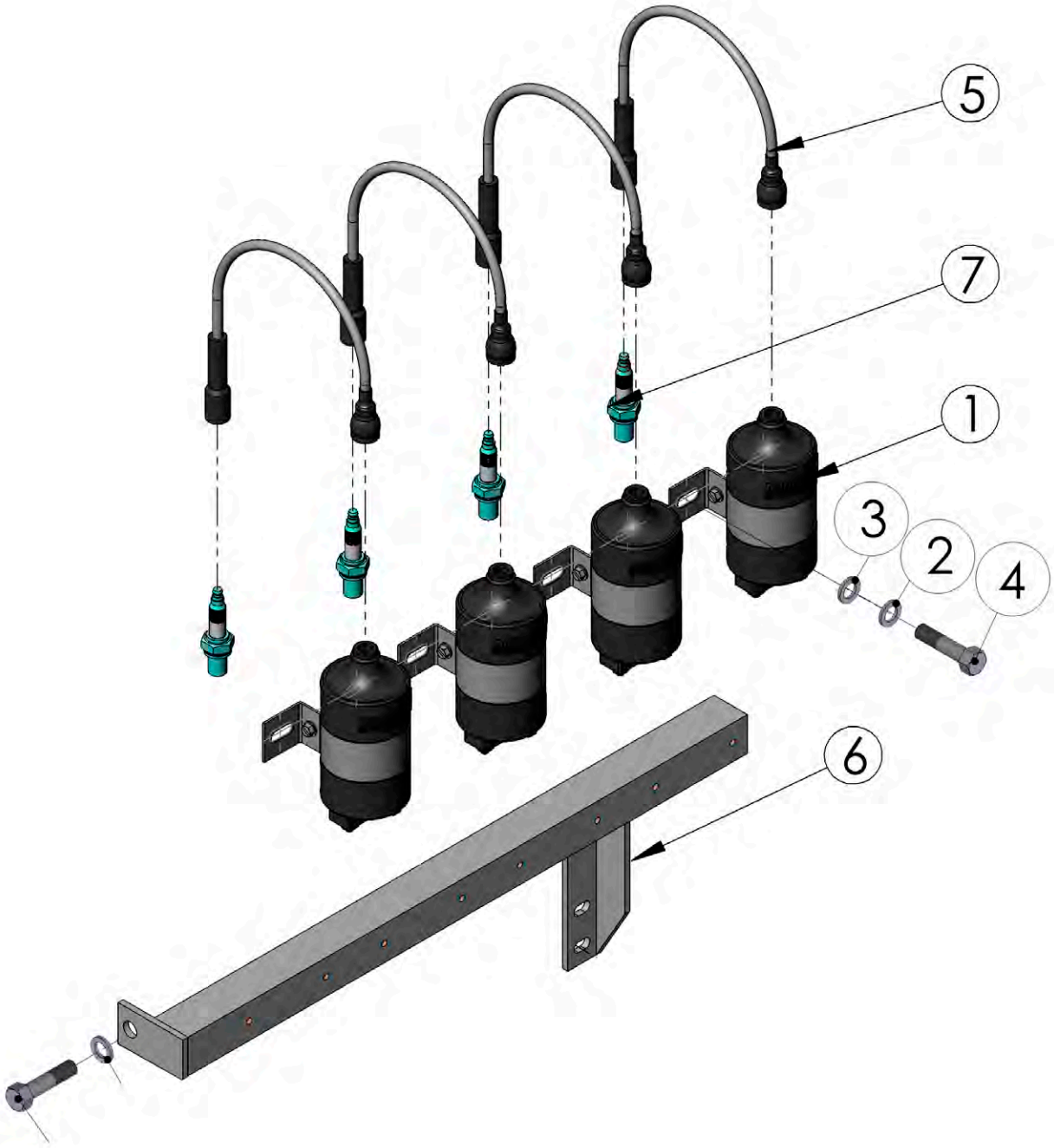
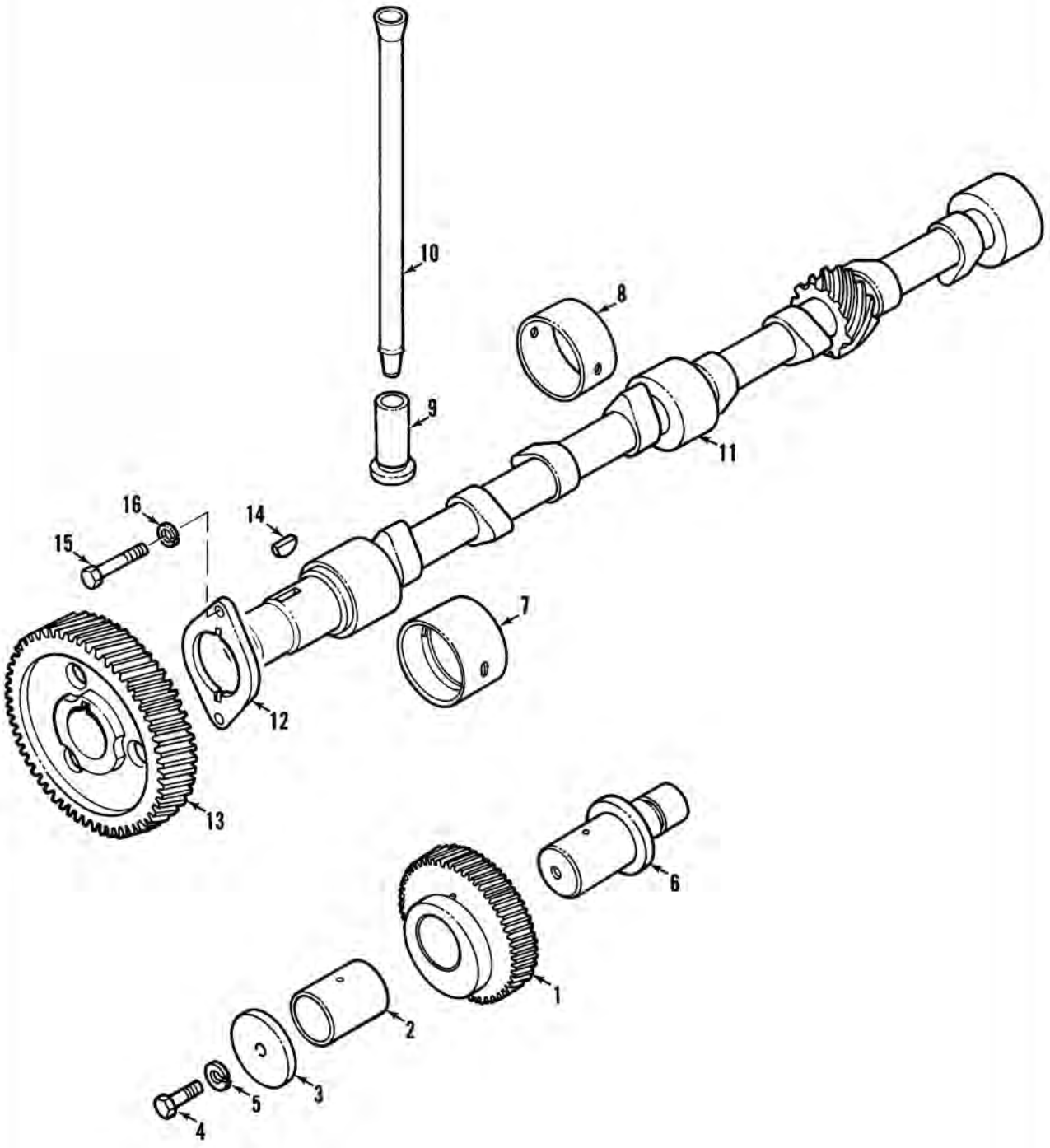


•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Coil Bracket
Groups 22, 26

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 22					
	A208391K-3CD	1	1	1	1	Bracket Assembly
	14AWG THHN-B				5	Wire, Black, 14 Gauge
1	330-2-AI-46				6	Coil, Ignition
	AES-65				1	Eyelet, Large Hole
	AES-66				11	Eyelet, Small Hole
	7930486				1	Harness
2	1A-1/4				12	Lockwasher, Plated
3	1N-1/4				12	Washer, Flat, SAE Plated
	29A-1/420				12	Nut, Hex, Zinc Plated
4	7A-1/420x3/4				12	Capscrew, Hex Head
5	163505B				6	Cable, Ignition
6	208391K				1	Bracket, Coil Mtg. Zinc Plated
	GROUP 26					
7	69462	4	6	6		Spark Plug
	69462-CF				6	



CAMSHAFT, VALVE LIFTER, PUSH ROD, IDLER GEAR

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Camshaft, Lifter, Valve, Push Rod, Idler Gear

Groups 15, 20, 23

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 15					
	A216015A	1	1	1	1	Gear, Idler - Assembly
1	•216015A	1	1	1	1	Gear, Idler - Assembly
2	•216029A	1	1	1	1	Bushing, Idler Gear
3	169420D	1	1	1	1	Washer, Thrust
4	28152	1	1	1	1	Screw, Cap, Hex Head, 5/16” - 24 x 7/8”
5	1A-5/16	1	1	1	1	Washer, Lock, 5/16”
6	208514	1	1	1	1	Spindle, Idler Gear
	GROUP 20					
7	216050	1	1	1	1	Bushing, Camshaft - Front (Undersize for Align-boring)
	216050S	1	1	1	1	Bushing, Camshaft - Front (Pre-reamed to Size)
8	216053	2	3	3	3	Bushing, Camshaft - Center and Rear (Undersize for Align-boring)
	216053S	2	3	3	3	Bushing, Camshaft (Pre-reamed to Size)
9	180037C	8	12	12	12	Lifter, Valve
10	216038	8	12	12		Rod, Push
	216138				12	
	GROUP 23					
	A216123F	1				Camshaft Assembly
	A217123G		1	1		
	A217023CF				1	
11	•216123F	1				Camshaft
	•217123G		1	1		
	•217023CF				1	
12	•208509	1	1	1	1	Plate, Thrust
13	•216026	1	1	1	1	Gear, Camshaft
14	•104A-#6	1	1	1	1	Key, Woodruff, No. 6
15	7A-1/420X5/8	2	2	2	2	Screw, Cap, Hex Head, 1/4” - 20 x 5/8”
16	1A-1/4	2	2	2	2	Washer. Lock, 1/4”
	KITS					
	927-46	1				Camshaft Bushing Kit (Includes Items 7 & 8 Undersize Bushings)
	927-48		1	1	1	
	927-50		1	1	1	Camshaft Bushing Kit (Includes Items 7 & 8 Pre-reamed Bushings)
	927-52		1	1	1	

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

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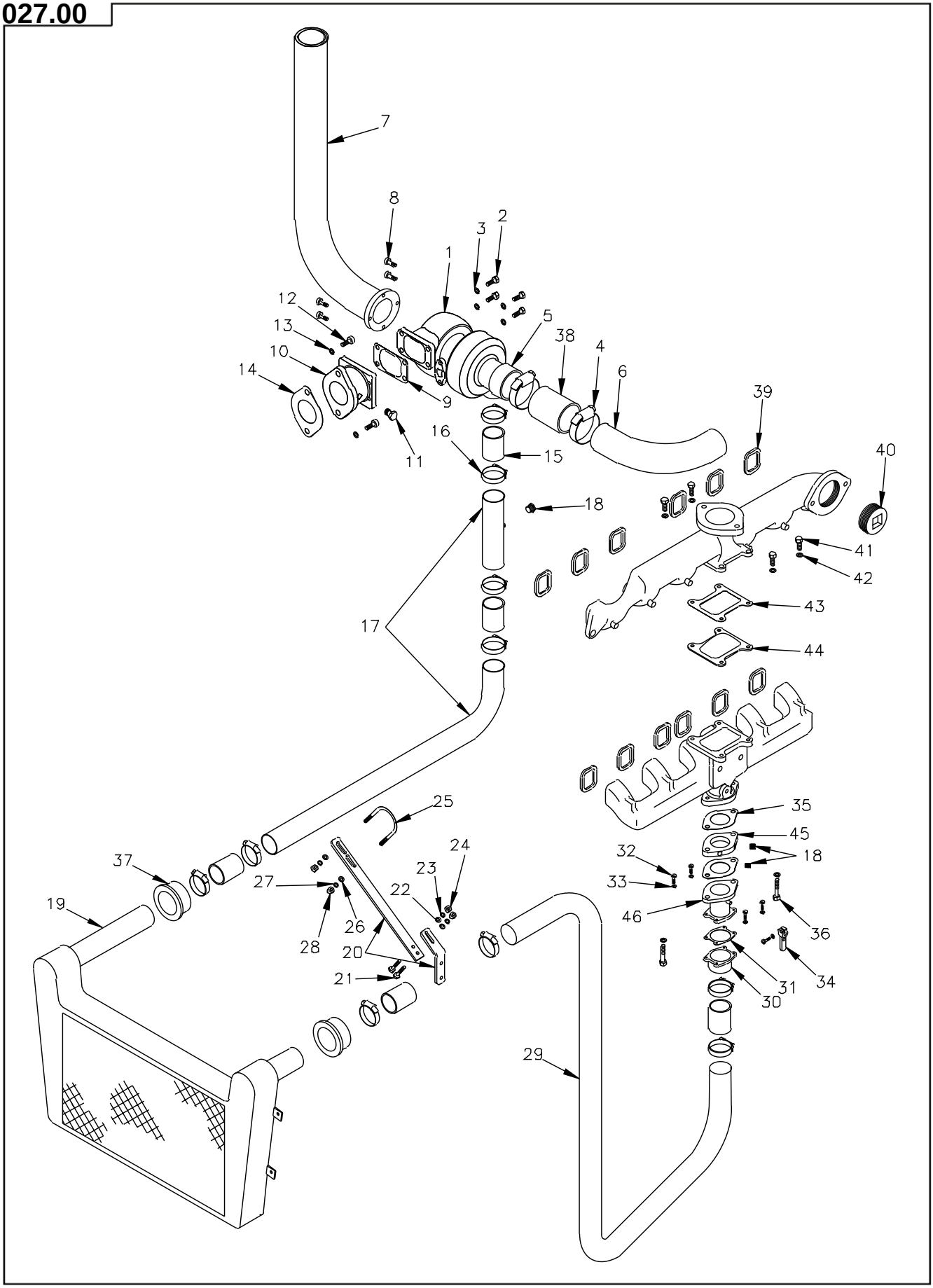


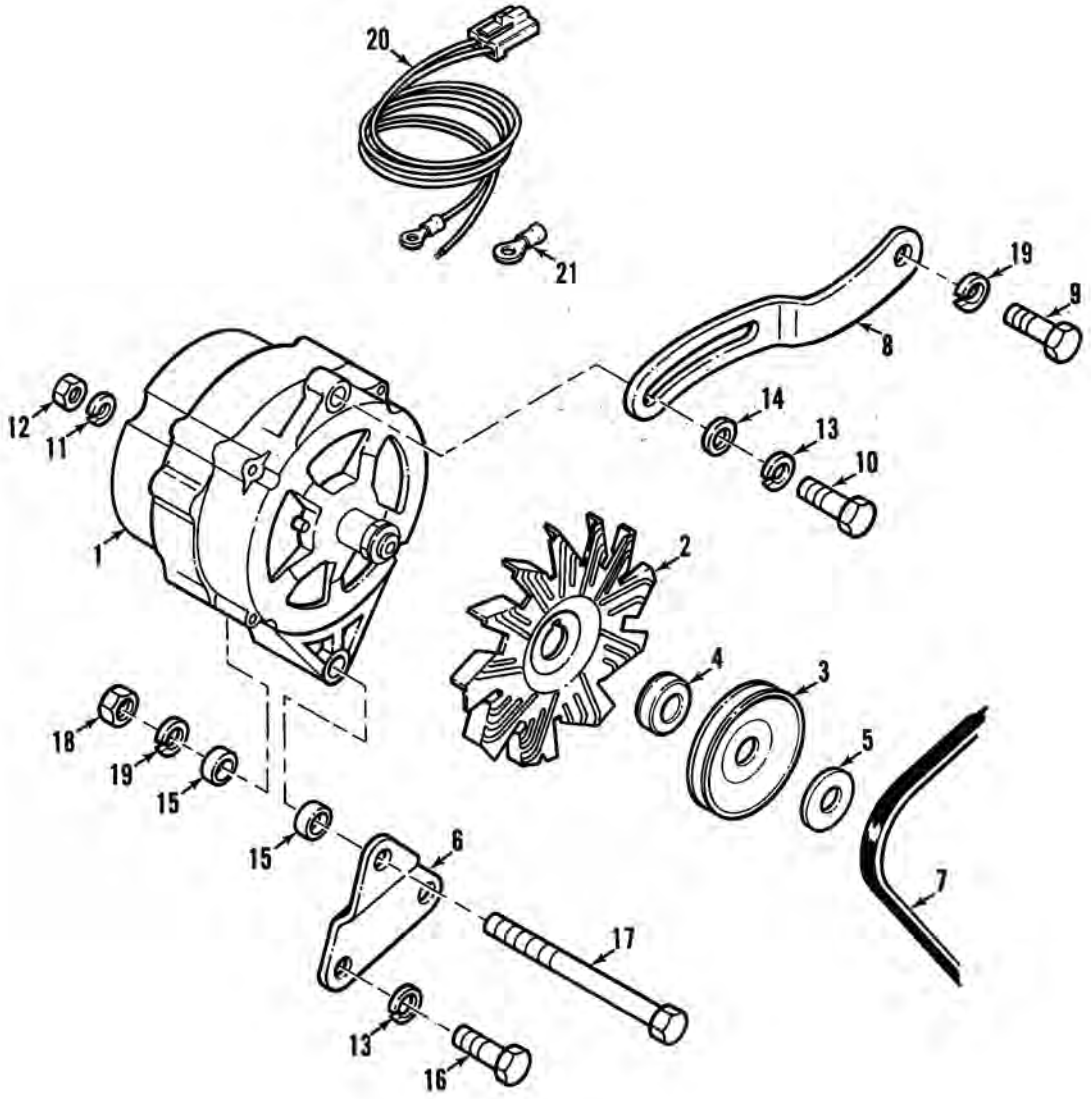
•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Turbocharger with Intercooler

Groups 27, 29

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	208563B			1		Turbocharger
2	7A3/816x1			4		Capscrew, Hex Head
3	1A-3/8			6		Washer, Lock, 3/8”
4	41236			2		Clamp, Hose
5	332-TS4-66A			1		Rubber Bushing, 2 1/4” x 1 1/4”
6	161592E			1		Tube, Carburetor to Turbocharger
7	216099T			1		Elbow, Exhaust Outlet
8	7B-8x20			4		Capscrew, SKT HD 8-1.25 x 18mm
9	208594A			1		Gasket, Adapter Inlet
10	211037			1		Adapter, Turbo Inlet
11	26411			1		Plug, SKT HD Pipe 3/8”
12	26461			2		Capscrew, SKT HD 1/2” - 13 x 1 1/4”
13	1A-1/2			2		Washer, Lock, 1/2”
14	207379			1		Gasket, Adapter Inlet
15	169058			5		Hose, 2” x2.5”
16	HC-28			10		Hose, Clamp 3.06 - 4.0
17	A209666L			1		Tubes, Air Outlet to Intercooler
18	PF18-1/4			3		Plug, SKT HD Pipe 1/4”
19	211130			1		Intercooler
20	211042A			1		Bracket, Tube Support
21	7A-1/420x1			2		Capscrew, Hex Head 1/4” - 20 x 1”
22	1N-1/4			2		Washer, Flat, 1/4”
23	1A-1/4			2		Washer, Lock, 1/4”
24	29A-1/420			2		Nut, Hex, 1/4” - 20
25	42030			1		U-Bolt, 5/16” - 18 x 2” x 2 11/16”
26	1N-5/16			2		Washer, Flat, 5/16”
27	1A-5/16			1		Washer, Lock, 5/16”
28	29A-5/1618			2		Nut, Hex Head, 5/16” - 18
29	209666R			1		Tube, Intercooler to Throttle Body
30	29A-1/213-2			1		Adaptor, Throttle Body
31	G1-11			1		Gasket, Throttle Adaptor
32	9A-1032x1/2			4		Capscrew, SKT HD 10 - 32 x 1/2”
33	1A-#10			4		Washer, Lock, #10
34	AL1-9-1			1		Lever, Throttle
35	G1-23			2		Gasket, Throttle to Intake
36	7A-3/816x13/4			2		Capscrew, Hex Head 3/8” - 16 x 1 3/4”
37	208853			2		Adaptor, Rubber
38	1257-795A			1		Hose, 2 3/4” x 2 7/8”
39	159883			12		Gasket, Intake and Exhaust Manifold
40	Y9097			1		Plug, Pipe 2 1/2”
41	7A-3/816X1			4		Screw, Hex Head, 3/8” x 1.0
42	1A-3/8			4		Washer, Lock, 3/8”
43	159884			1		Gasket, Intake to Exhaust
44	211204			1		Plate, Spacer
45	29A-1/213-1			1		Spacer, Throttle Body
46	29A-1/213			1		Throttle, Body
	A217142A			1		Manifold Assembly
	159883			1		Manifold Gaskets
	500010			1		Actuator
	199982			1		Oil Filter
	330TA			1		Kit to Convert Engine from Naturally Aspirated to Turbocharged

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE



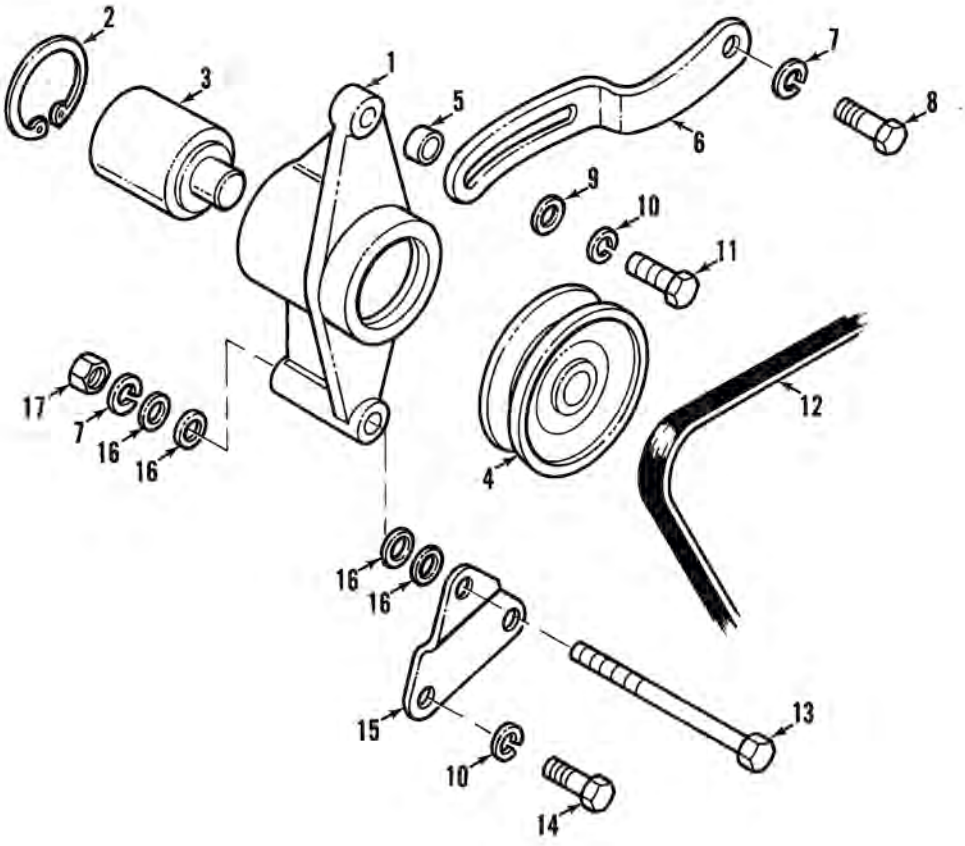
ALTERNATOR

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Alternator
Group 28

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	69753A	1	1	1	1	Alternator (Standard)
	24V ALT	1	1	1	1	Alternator, 24 Volt (Optional)
	•485041	1	1	1	1	Regulator, Voltage (Not Sold Separately)
	•485040	1	1	1	1	Brush, Spring and Holder Assembly
	•490976	1	1	1	1	Regulator, Voltage
2	69451	1	1	1	1	Fan, Alternator
3	216096E	1	1	1	1	Pulley, Alternator (Bracket Mounted Fan)
4	216096F	1	1	1	1	Collar, Alternator Pulley (Bracket Mounted Fan)
5	154084	1	1	1	1	Spacer (Bracket Mounted Fan)
6	216073	1	1	1	1	Bracket, Alternator Mounting
7	154337	1	1	1	1	Belt, Alternator (Bracket Mounted Fan)
	A154337	1	1	1	1	Belt, Alternator (Set of Two Belts - Water Pump Mounted Fan)
8	199094C	1	1	1	1	Strap, Adjusting (Bracket Mounted Fan)
	199094D	1	1	1	1	Strap, Adjusting (Water Pump Mounted Fan)
9	7A-3/816X1/2	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16x5/8” (Bracket Mounted Fan)
	7A-3/816X1	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16x1” (Water Pump Mounted Fan)
10	7A-5/1618X3/4	1	1	1	1	Screw, Cap, Hex Head - Plated M8x5/16” - 18 x 3/4”
11	1A-3/8	1	1	1	1	Washer, Lock, 3/8”
12	29A-3/816	1	1	1	1	Nut, Hex, 3/8” - 16
13	1A-5/16	3	3	3	3	Washer, Lock, 5/16”
14	1N-5/16	1	1	1	1	Washer, Plain, 5/16”
15	63809X	2	2	2	2	Spacer
16	7A-5/1618X3/4	2	2	2	2	Screw, Cap, Hex Head, 5/16” - 18x3/4”
17	21370	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16x3 1/4”
18	29A-3/816	1	1	1	1	Nut, Hex, 3/8”-16
19	1A-3/8	2	2	2	2	Washer, Lock, 3/8”
20	A199914	1	1	1	1	Wire, Alternator Assembly
21	Y18984C	1	1	1	1	Terminal Wire

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

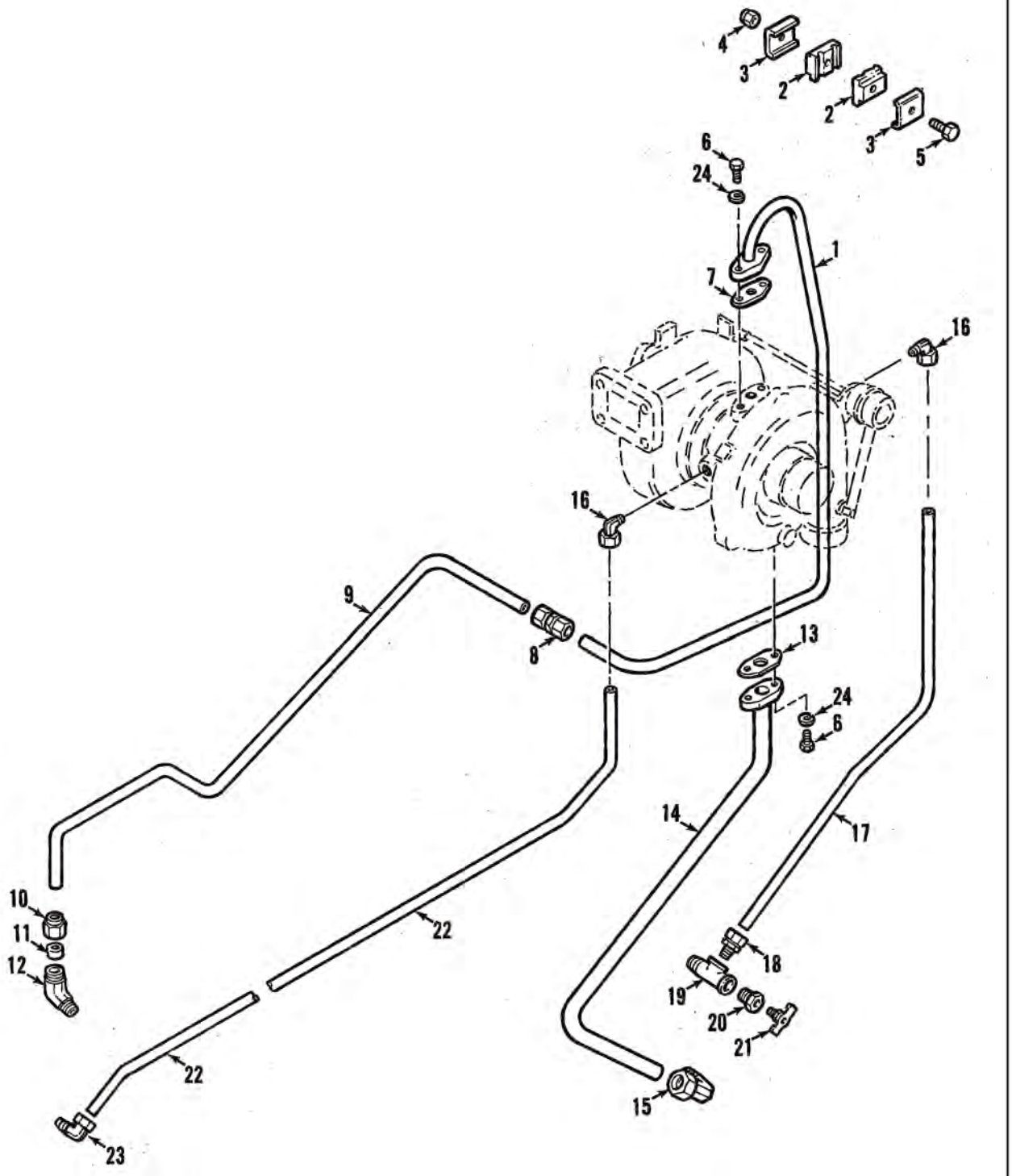


BELT TIGHTENER

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Belt Tightener
Group 28

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	C199582A	1	1	1	1	Tightener, Belt - Assembly (With Bracket Mounted Fan)
1	•199582A	1	1	1	1	Tightener, Belt
2	•4499R	2	2	2	2	Ring, Retaining
3	•199583	1	1	1	1	Shaft/Bearing, Belt Tightener
4	•216096G	1	1	1	1	Pulley, Belt Tightener
	199096B	1	1	1	1	Pulley, 2 Groove
5	80297M	1	1	1	1	Spacer
6	199094C	1	1	1	1	Strap, Adjusting
	199094D	1	1	1	1	Strap, Adjusting, Fan Mounted Water Pump
7	1A-3/8	2	2	2	2	Washer, Lock, 3/8”
8	7A-3/816X1/2	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 15 x 5/8”
9	B277	1	1	1	1	Washer, Plain, 5/16”
10	1A-5/16	3	3	3	3	Washer, Lock, 5/16”
11	7A-8/1618X1	1	1	1	1	Screw, Cap, Hex Head, 5/16 - 18 x 1”
12	154337	1	1	1	1	Belt, Water Pump
13	21370	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16 x 3 1/4”
14	7A-5/1618X3/4	2	2	2	2	Screw, Cap, Hex Head, 5/16” - 18 x 3/4”
15	216073	1	1	1	1	Bracket, Alternator Mounting
16	1N-3/8	4	4	4	4	Washer, Plain, 3/8”
17	29A-3/816	1	1	1	1	Nut, Hex, 3/8” - 16
18	A199582B	1	1	1	1	Idler Bracket Assembly
19	A199582C	1	1	1	1	Idler Bracket Assembly, Adjustable



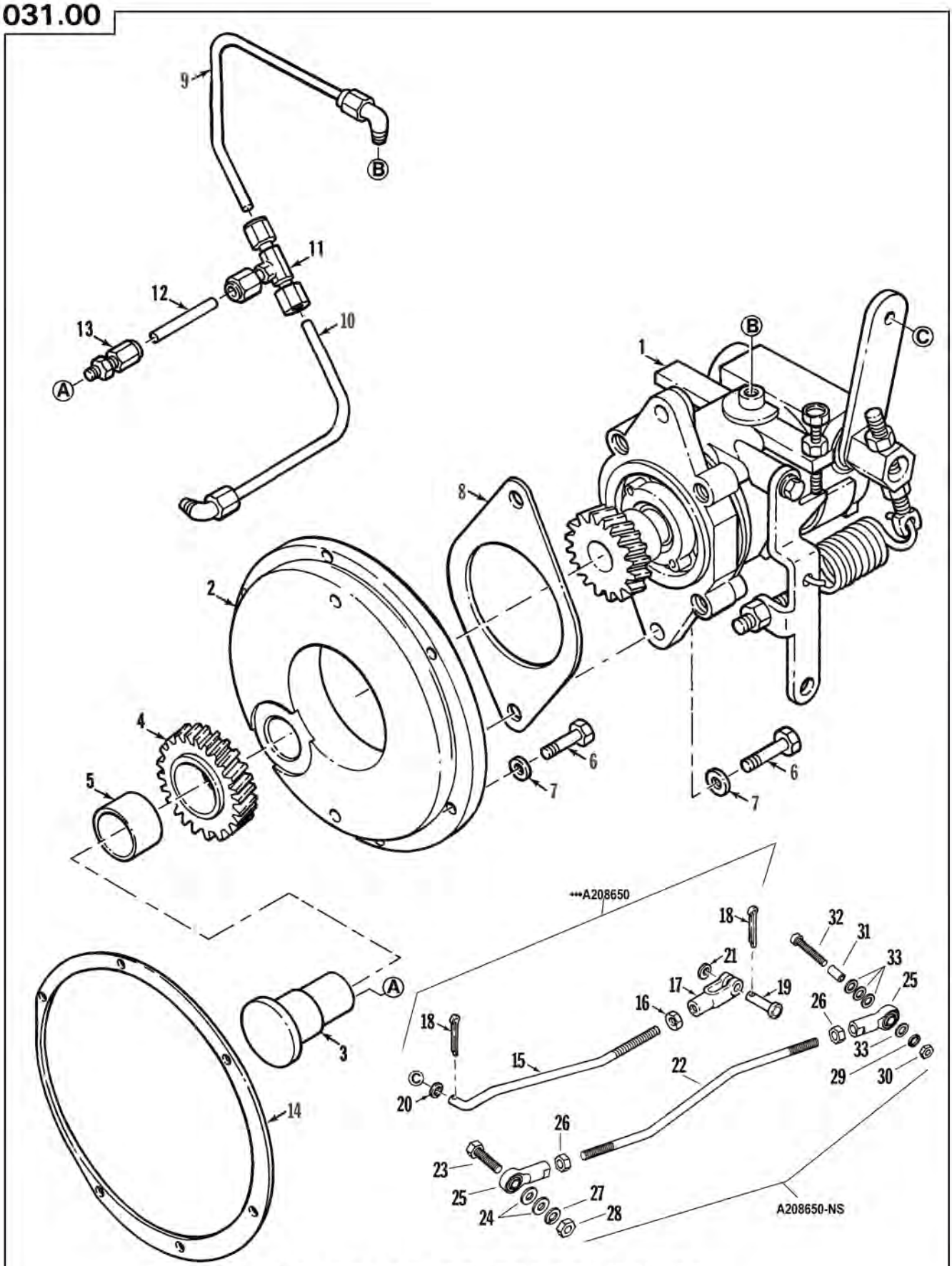
TURBOCHARGER OIL, WATER SUPPLY

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Turbocharger Oil Supply
Group 29

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	A211129J			1		Tube, Oil Supply - Assembly
2	207588C			2		Inset, Tube Clamp
3	207587C			2		Clamp, Tube
4	33A-1/420			1		Nut, Flex Loc, 1/4” - 20
5	7A-1/420X11/4			1		Screw, Cap, Hex Head, 1/4” - 20 x 1 1/4”
6	294524			4		Screw, Cap, Hex Head, M8 x25mm
7	169329A			1		Gasket, Turbo Oil
8	199108C			1		Union, Tube
9	21129K			1		Tube, Oil Supply
10	120919			1		Nut, Tubing
11	119996			1		Sleeve, Rubber
12	208670E			1		Elbow, Reducing - Brass, 5/8” to 1/4” x 45°
13	16329			1		Gasket, Turbo Oil Drain
14	A211128C			1		Tube, Oil Drain
15	199111P			1		Nut, Tubing
16	199111S			2		Elbow, 90°, Pipe to Tube
17	211410			1		Tube, Water Return
18	194769H			1		Connector, Flex
19	78920C			1		Tee, Service, 1/2”
20	78212C			1		Bushing, Reducing, 1/2” to 1/4”
21	76400			1		Cock, Drain
22	211141C			1		Tube, Water Supply
23	199111K			1		Elbow, Flex
24	293335			1		Washer, Spring, M8

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE



GOVERNOR, GOVERNOR LINKAGE

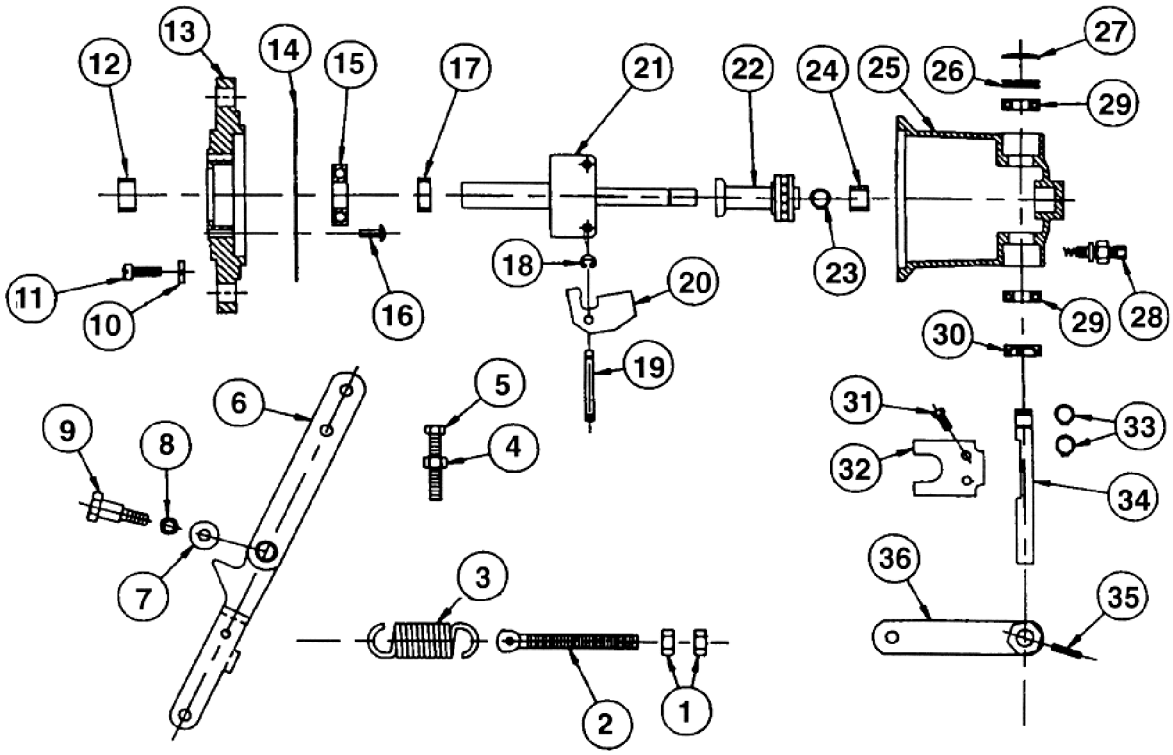
•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Mechanical Governor & Linkage

Groups 22, 26

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 31					
	D68031E	1	1	1		Governor Assembly (Items 1-15)
1	•68031E	1	1			Governor (Standard Engine)
	•216092	1	1	1		Gear, Governor Drive
2	•208632	1	1	1		Adaptor, Governor Drive
3	•208633	1	1	1		Spindle, Governor Idler Gear
4	•A216028	1	1	1		Gear, Governor Idler - Assembly
5	•208634	1	1	1		Bushing, Governor Idler Gear
6	26939	8	8	8		Screw, Cap, Hex Head, 3/8” - 16 x 1”
7	B2135	8	8	8		Washer, Copper
	A208657C	1	1	1	1	Governor Lube Assembly, New Style
8	••208666	1	1	1	1	Gasket, Governor
9	••211078ZA	1	1	1	1	Braided Hose, Top, to Governor
10	••211078YA	1	1	1	1	Braided Hose, Bottom, to Block
11	••211144A	1	1	1	1	Tee
12	••48x4	1	1	1	1	Fitting, Straight, Block
13	••49x4	1	1	1	1	Elbow, 90, Governor
14	••208635	1	1	1		Gasket, Adaptor Plate
	GROUP 33					
	A208651	1				Rod, Governor - Assembly
	A208650-NS		1			
15	•208651	1				Rod, Governor
16	•30A-1032	1	1	1		Nut, Hex, No 10-32
17	•116508	1	1	1		End, Governor Rod
18	2A-1/16x1/2	2	2	2		Pin, Cotter, 1/16” x 1/2”
19	B3743	1	1	1		Pin, Rod End
20	Y18813E	1	1	1		Washer, Plain, 3/8”
21	73448	1				Washer, Plain, 17/64”
	1N-1/4		1	1		Washer, Plain, 1/4”
22	•208650-NS	1	1	1		Throttle, Control
23	•7A-1/420x1	1	1	1		Capscrew, Hex Head
24	•73448	3	3	3		Washer, 17/64” x 1/2 x 1/16
25	•312-106	2	2	2		Ball Joint, Rod End
26	•29A-1/428	2	2	2		Nut, Hex, Finished
27	•1A-1/4	1	1	1		Lockwasher, Plated
28	•27A-1/420	1	1	1		Nut, Hex, Jam Heavy
29	•1A-#10	1	1	1		Lockwasher, Plated
30	•30A-1024	1	1	1		Nut, Machine Screw
31	•208650T	1	1	1		Tubing for 208650-NS
32	•12E-1024x11/4	1	1	1		Screw, Fillister Machine
33	•93-A-46	4	4	4		Washer, #8 Flat

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

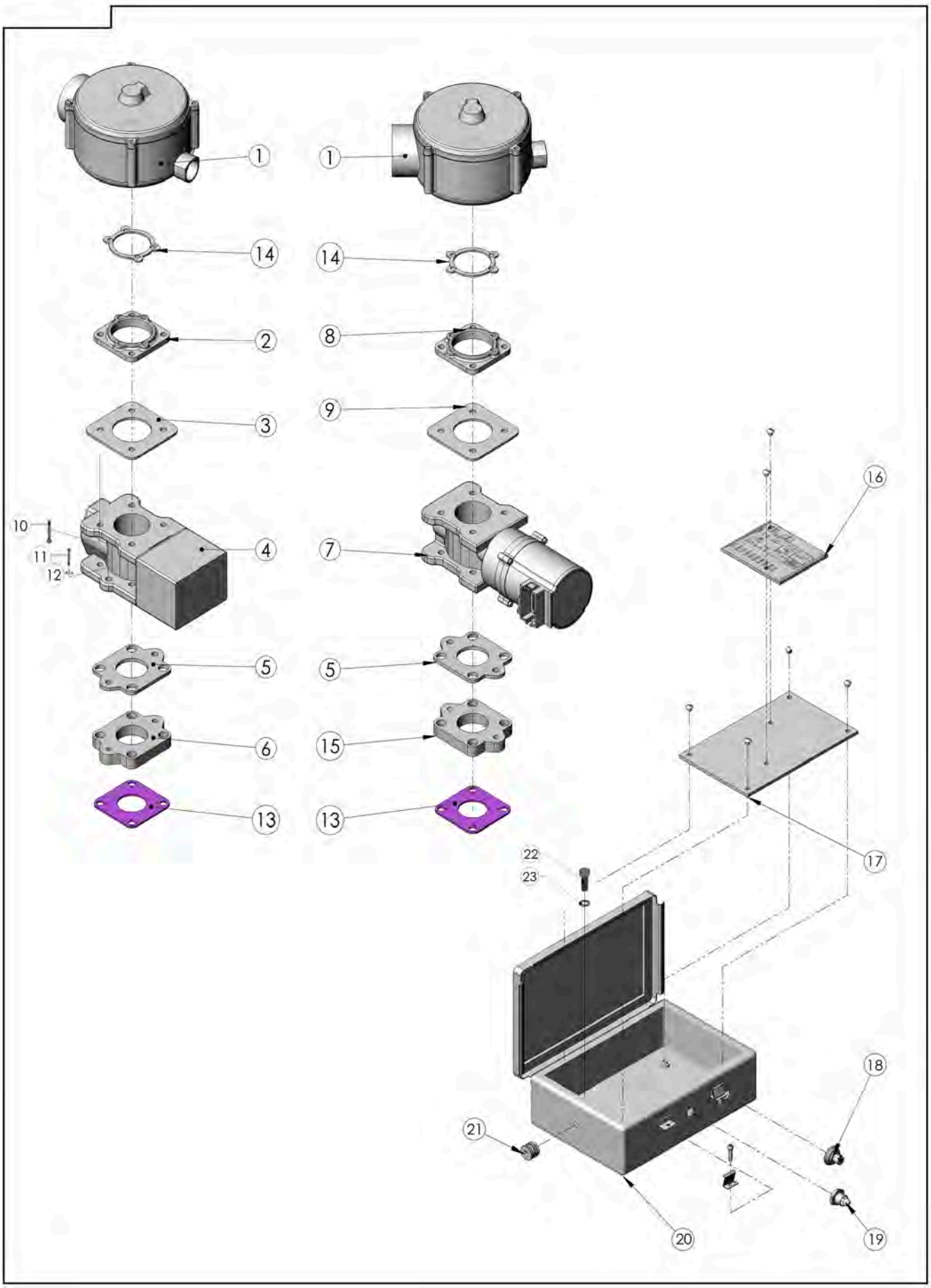


•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

68031 E Governor Assembly

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	494000	1	1			Nut
2	494001	1	1			Eyebolt
3	494002	1	1			Spring
4	494003	1	1			Nut
5	494004	1	1			Screw, Speed Stop
6	494005	1	1			Speed Control Lever
7	494006	1	1			Washer
8	494007	1	1			Spacer, Shim
9	494008	1	1			Bolt, Lever Pivot
10	494009	1	1			Lockwasher
11	494010	1	1			Screw, Cover to Body
12	494011	1	1			Spacer, Gear to Bearing
13	494012	1	1			Cover
14	494013	1	1			Gasket, Cover to Body
15	494014	1	1			Bearing, Front Main
16	494015	1	1			Rivet, Bearing to Cover
17	494016	1	1			Spacer, Bearing to Yoke
18	494017	2	2			Retainer
19	494018	2	2			Pin, Flyweight
20	494019	2	2			Flyweight
21	494020	1	1			Main Shaft and Yoke
22	494021	1	1			Thrust Sleeve and Bearing
23	494022	1	1			Retainer
24	494517	1	1			Bearing, Rear Housing
25	494023	1	1			Body
26	494024	1	1			Spacer, Expansion Plug
27	494523	1	1			Expansion Plug
	494523J	1	1			Cup Style Freeze Plug (Larger OD)
28	494031	1	1			Bumper Screw
29	494518	2	2			Bearing, Rocker Shaft
30	494521	1	1			Oil Seal, Rocker Shaft
31	494025	1	1			Screw, Lever to Shaft
32	494026	1	1			Lever, Rocker
33	494027	1	1			Retainer
34	494028	1	1			Shaft, Rocker
35	494029	1	1			Pin, Lever to Shaft
36	494030	1	1			Throttle Lever
38	RP68031E	1	1			Governor Repair Kit

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

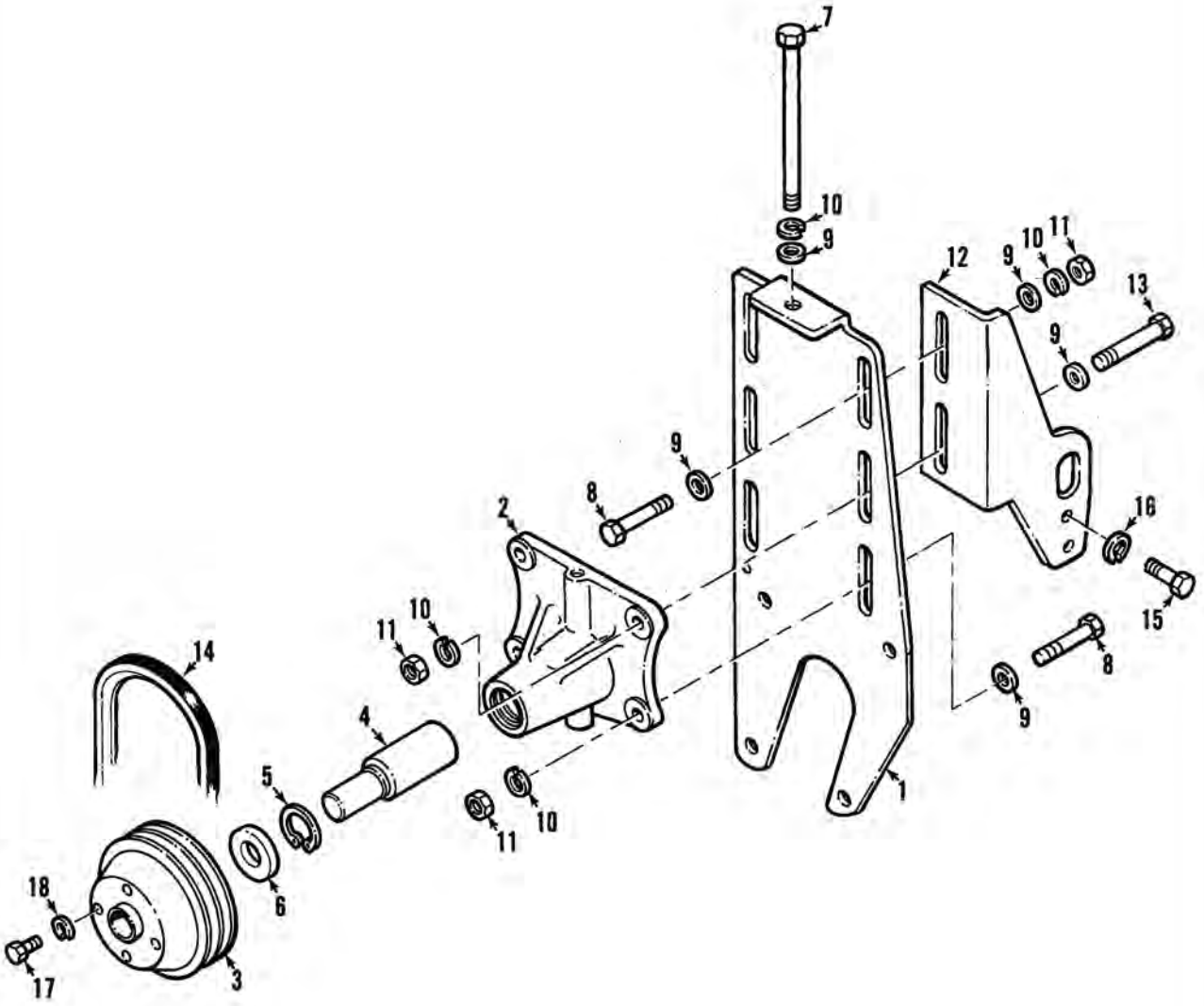


•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Electronic Governor Assembly

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GOVERNOR					
1	199097A		1	1	1	Arrow 100 Carburetor
	6321-CF		1	1	1	GAC ATB Integral Body Governor Assembly
2	•N00-4097A		1	1	1	Carb to Governor Adaptor
3	8404G		1	1	1	Carb to Governor Gasket
4	•6321		1	1	1	GAC ATB Integral Body Governor, 45mm
5	•261-106		1	1	1	Governor to Intake Manifold Gasket
6	•6321-CF-ADAP-TOR				1	Governor Adaptor
7	8404-2008		1	1	1	Woodward Governor, 43mm
	8404-2009		1	1	1	Woodward Governor, 50mm
8	8404-A42		1			Woodward Governor to Carburetor Adaptor
9	8404G		1			Gasket
10	12E-1224x1		1	1	1	Screw
11	B291		1	1	1	Stud 3/8-24 x 3/8-16
12	IC-3/8		1	1	1	Star Washer
13	159884-A42		1	1		Gasket
14	G1-11		1	1	1	Gasket
15	•8404-A42		1	1		Adaptor
	8404-A54		1	1		
	8404-CF				1	
	SPEED CONTROL UNIT					
16	ESD-2210-12		1	1	1	Speed Controller, 12 volt
	ESD-2210-24		1	1	1	Speed Controller, 24 volt
17	•AS1-1-P		1	1	1	Mounting Plate for Speed Control Unit
18	•208435-1		1	1	1	Toggle Switch
19	6321-CB		1	1	1	Push Button
20	AS1-1		1	1	1	Box with Screws
21	•PF-5090		1	1	1	Fitting for Wiring
22	7A-3/816x1		4	4	4	Bolt
23	1A-3/84		4	4	4	Washer
	25A-3/816		4	4	4	Nut
	117428		1	1	1	Spacer
	•168000-1		1	1	1	Cover

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

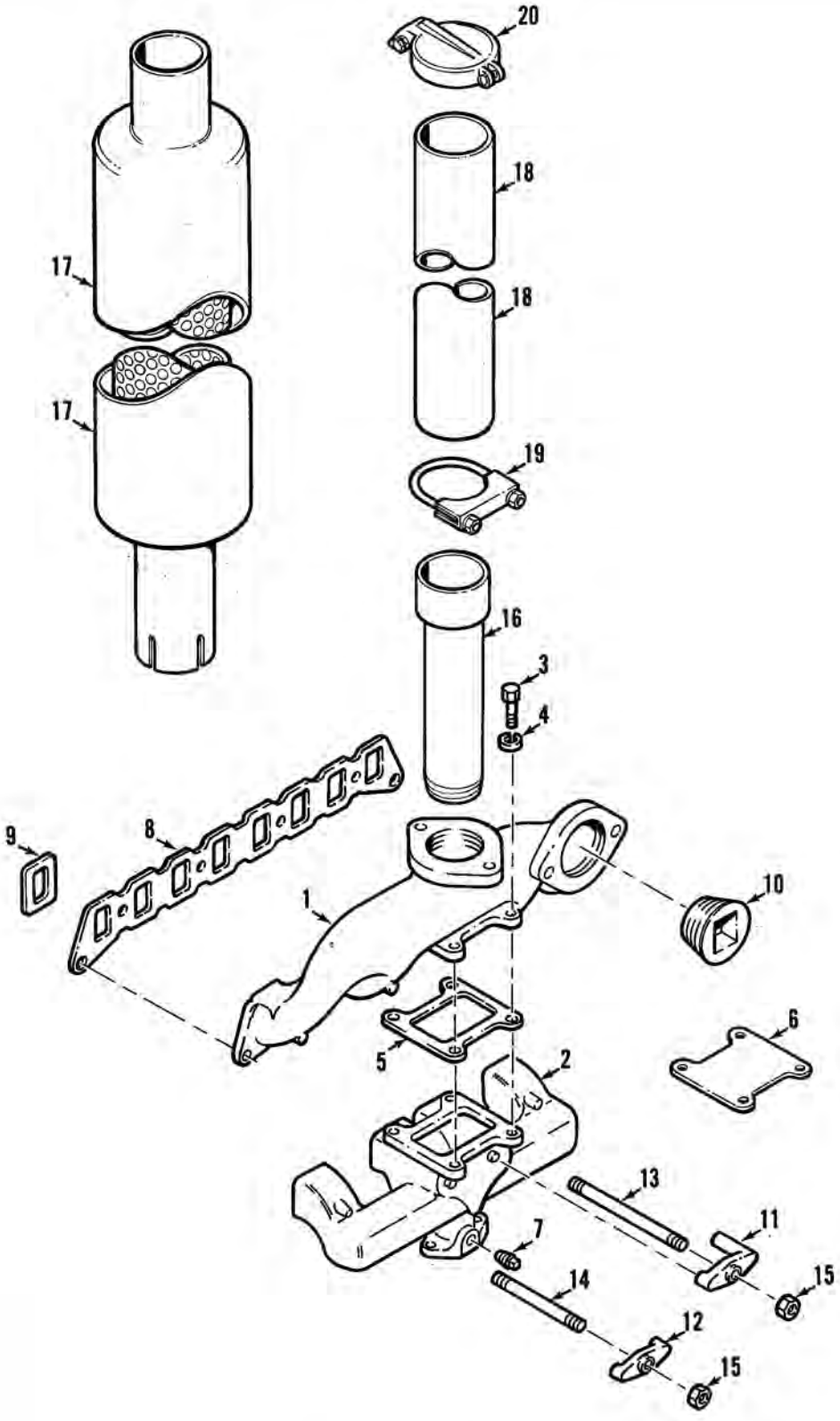


FAN BRACKET

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Fan Bracket
Group 32

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	V216032	1	1	1	1	Bracket, Fan, 16”
1	•216032	1	1	1	1	Bracket, Fan Adjustment
	•E208556	1	1	1	1	Housing, Fan - Assembly
2	••208556	1	1	1	1	Housing, Fan
3	••216094A	1	1	1	1	Pulley, Fan
4	••190156F	1	1	1	1	Shaft/Bearing, Fan
5	••44999R	1	1	1	1	Ring, Retaining
6	••153312A	1	1	1	1	Seal, Dust
7	•26241	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16 x 5 1/4”
8	•21354	4	4	4	4	Screw, Cap, Hex Head, 3/8” - 16 x 1 3/8”
9	•76911	7	7	7	7	Washer, Plain, 13/32”
10	•1A-3/8	5	5	5	5	Washer, Lock, 3/8”
11	•29A-3/816	5	5	5	5	Nut, Hex, 3/8” (16” Fan Height)
12	•208928	1	1	1	1	Support, Fan Adjustment Bracket
13	•7A-3/816X13/4	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16 x 1 3/4”
14	A216003D	1	1	1	1	Belt, Fan (Set of Two Matched Fan Belts)
	A216003B					
15	29605	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 1”
16	1A-3/8	2	2	2	2	Washer, Lock, 3/8”
17	7A-5/1618X3/4	4	4	4	4	Screw, Cap, Hex Head, 5/16” - 18 x 3/4”
18	1A-5/16	4	4	4	4	Washer, Lock, 5/16”



INTAKE, EXHAUST MANIFOLD

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Intake and Exhaust Manifold

Groups 43, 217

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 43					
	A216142	1				Manifold Assembly
	A217142		1			
	A217142A			1		
1	•216142	1				Manifold, Exhaust
	•217142		1			
	•217142A			1		Manifold, Exhaust, Heat Treated
2	•216141	1				Manifold, Intake
	•217141		1	1		
3	•7A-3/816X1	4	4	4		Screw, Cap, Hex Head, 3/8” - 16 x 1”
4	•1A-3/8	4	4	4		Washer, Lock, 3/8”
5	•159884	1	1	2		Gasket, Intake to Exhaust Manifold
6	•211204			1		Plate, Spacer
	211204-1			1		Plate, Spacer, Upper Curved Plate
	211204-2			1		Plate, Spacer, Lower Flat Plate
7	78282A	1	1	1		Plug, Pipe, Square Head, 1/8”
8	208596	1				Gasket, Intake and Exhaust Manifold
	208597		1			
9	159883			12		
10	Y9097	1	1	1		Plug, Pipe, Contersunk Headless, 2 1/2”
	208595	1	1	1		Gasket, For 2 1/2” Plug
11	158978	2	2	2		Clamp, Manifold
12	158978A	2	4	4		Clamp, Manifold
13	107120	2	2	2		Stud
14	74358	2	4	4		Stud
15	B2943	4	6	6		Nut, Hex, 3/8” - 24
	GROUP 217					
16	A100907U	1	1			Connection, Exhaust
17	199454A	1	1	1	1	Muffler
	199454A-SA	1	1	1	1	Muffler, Critical Grade
18	152802	2	2	2	2	Straps, Muffler
	152802-SA	2	2	2	2	Straps, Muffler, Critical Grade
19	155938T	1	1	1	1	Rain Cap
	155938	1	1	1	1	Rain Cap, Critical Grade
20	168094	1	1			Clamp, Exhaust
21	207426	1	1			Pipe, Exhaust (Less Muffler)
22	7A-5/1618x11/4	4	4	4	4	Screw, Cap, Hex Head, 5/16” - 18 x 1 1/4”
23	1A-5/16	4	4	4	4	Washer, Lock, 5/16”
	500002	1	1			Manifold, Water Cooler

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

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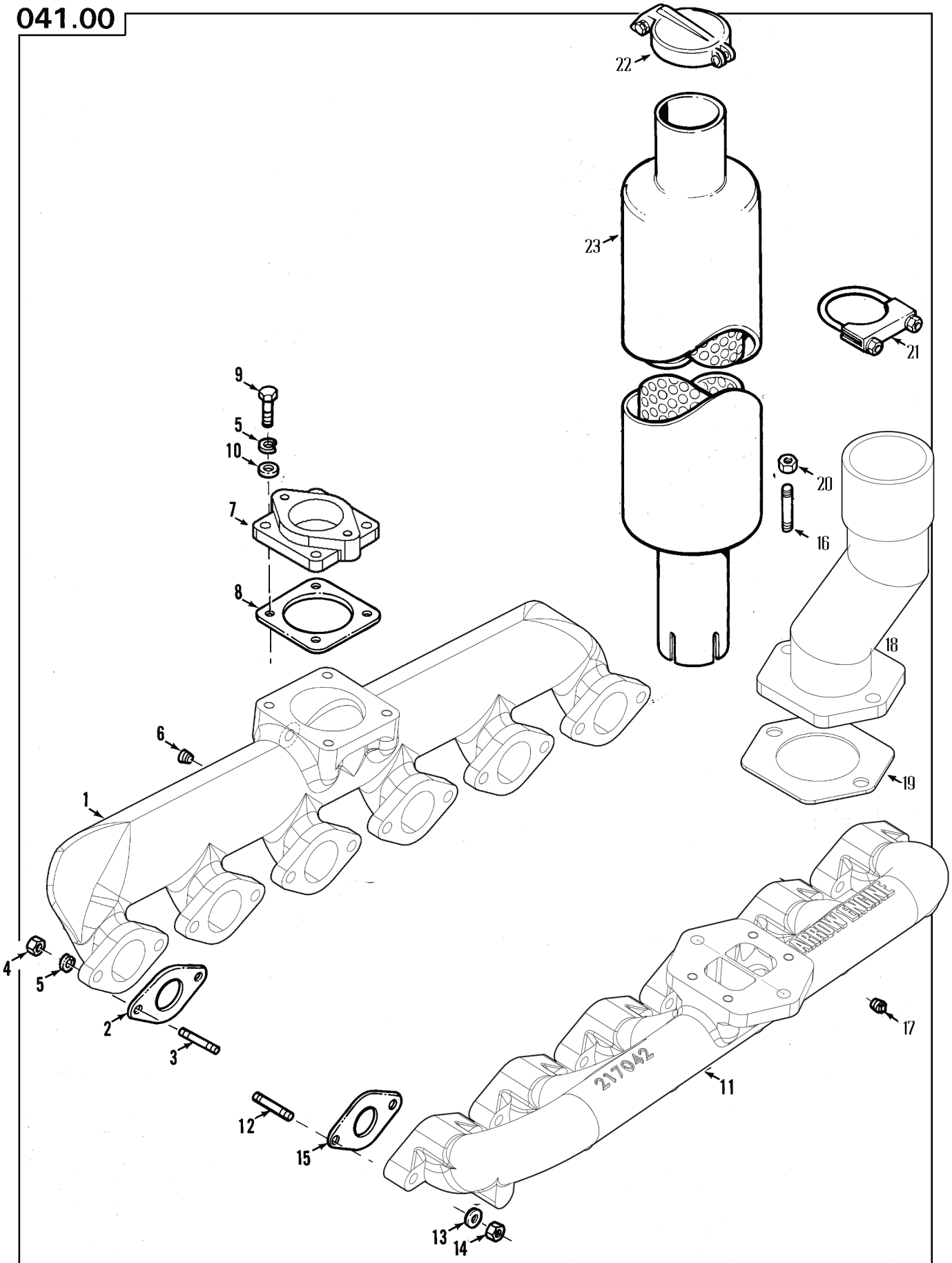

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Intake and Exhaust Manifold

Groups 41, 42, 217

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 41					
1	217041				1	Manifold, Intake
2	166595A				6	Gasket, Intake Manifold
3	B654				12	Stud
4	21193				12	Nut, Hex, 3/8” - 24
5	1A-3/8				16	Washer, Lock, 3/8”
6	Y18802				1	Plug, Pipe, Allen Head, 1/8”
7	6321-CF-ADAP-TOR				1	Adaptor, GAC Governor
	8404-A42					Adaptor, Woodward Governor, Optional
8	208610				1	Gasket, Air Inlet Elbow
9	7A-3/816x1				4	Capscrew, Socket Head
10	1B-3/8				4	Washer, Plain, 3/8”
	GROUP 42					
11	217042				1	Manifold, Exhaust
12	B654B				12	Stud
13	B221				12	Washer, Plain, 3/8”
14	B2943				12	Nut, Hex - Bronze, 3/8” - 24
15	166629A				4	Gasket, Exhaust Manifold
16	7A-1/213x1				2	Bolt
17	26750				6	Plug, Pipe, Hex Head - Steel, 1/4”
	GROUP 217					
18	A100907-CFA54				1	Elbow, Exhaust
19	A100907-CF-G				1	Gasket, Exhaust Elbow
20	1A-1/2				2	Lockwasher
21	168094				1	Clamp, Muffler
22	155938T	1	1	1	1	Rain Cap
	155938	1	1	1	1	Rain Cap, Critical Grade
23	199454A	1	1	1	1	Muffler
	199454A-SA	1	1	1	1	Muffler, Critical Grade
24	152802	2	2	2	2	Straps, Muffler
	152802-SA	2	2	2	2	Straps, Muffler, Critical Grade
25	7A-5/1618x11/4	4	4	4	4	Screw, Cap, Hex Head, 5/16” - 18 x 1 1/4“
26	1A-5/16	4	4	4	4	Washer, Lock, 5/16”

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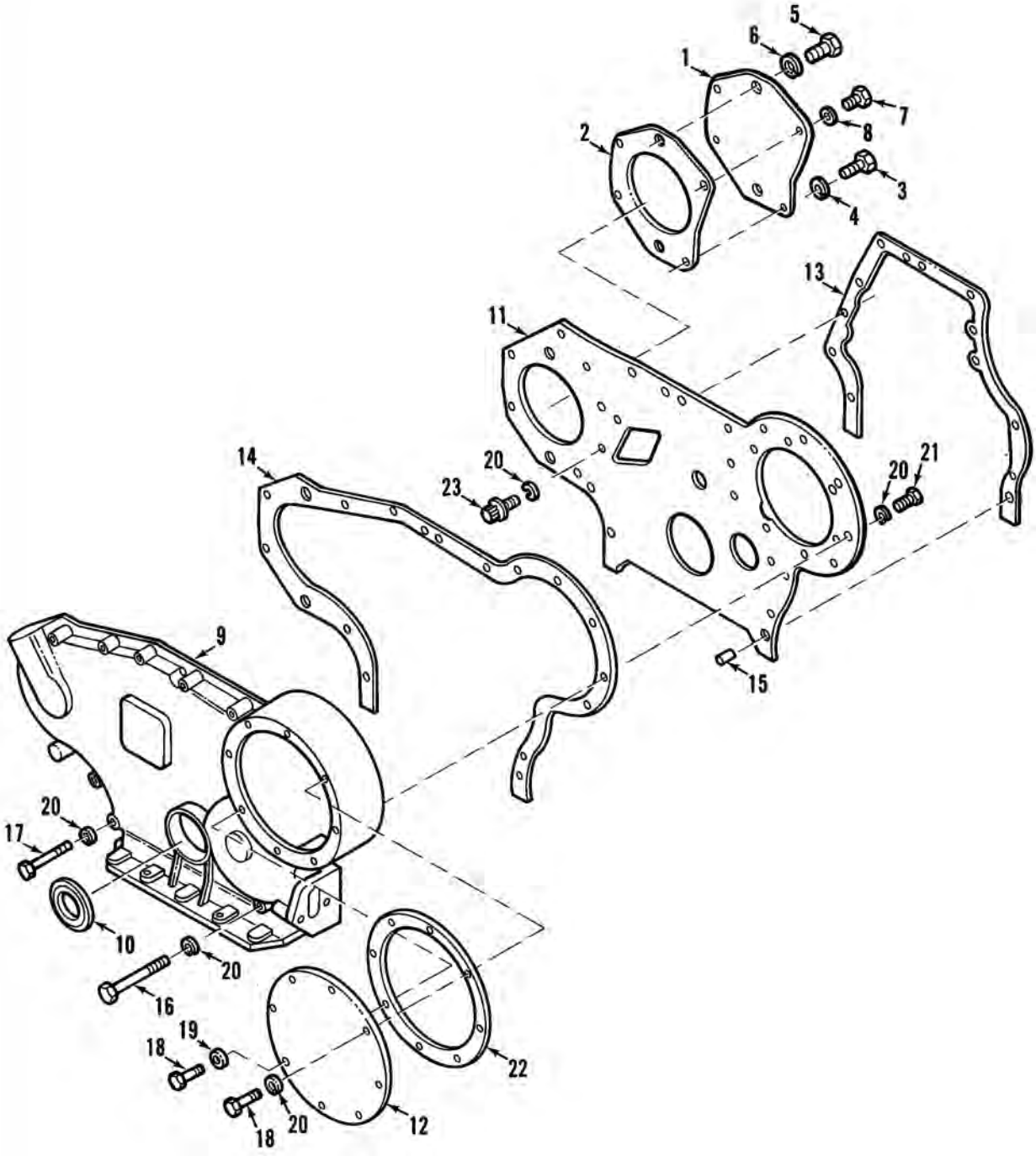

GEAR COVER

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Gear Cover
Groups 24, 45

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 24					
1	208647	1	1	1	1	Plate, Adaptor
2	208643	1	1	1	1	Gasket, Adaptor Plate
3	7A-5/1618X7/8	3	3	3	3	Screw, Cap, Hex Head, 5/16” - 18 x 7/8”
4	1A-5/16	3	3	3	3	Washer, Lock, 5/16”
5	7A-1/213X1	2	2	2	2	Screw, Cap, Hex Head, 1/2” - 13 x 1”
6	1A-1/2	2	2	2	2	Washer, Lock, 1/2”
7	7A-5/1618X1/2	1	1	1	1	Screw, Cap, Hex Head, 5/16” - 8 x 1/2”
8	B2135	1	1	1	1	Washer, Copper
	GROUP 45					
	C216045C	1	1	1	1	Cover, Gear - Assembly
9	216045C	1	1	1	1	Cover, Gear
10	•208526	1	1	1	1	Seal, Oil - Front
11	216054	1	1	1	1	Plate, Front
12	208512	1	1	1	1	Plate, Cover
13	208616	1	1	1	1	Gasket, Front Plate
14	208543	1	1	1	1	Gasket, Gear Cover
15	Y18678	2	2	2	2	Pin, Dowel
16	26348	1	1	1	1	Screw, Cap, Hex Head, 5/16” - 18 x 3”
17	21323	5	5	5	5	Screw, Cap, Hex Head, 5/16” - 18 x 21/2”
18	7A-5/1618X3/4	8	8	8	8	Screw, Cap, Hex Head, 5/16” - 18 x 3/4”
19	21950	2	2	2	2	Washer, Brass
20	1A-5/16	26	26	26	26	Washer, Lock, 5/16”
21	7A-5/1618X7/8	7	7	7	7	Screw, Cap, Hex Head, 5/16” - 18 x 7/8”
22	208513	1	1	1	1	Gasket, Cover Plate
23	28644	5	5	5	5	Screw, Cap, Ferry Head, 5/16” - 18 x 7/8”
	B4296	1	1	1	1	Gasket, Cap
	176412	1	1	1	1	Gasket, Cap

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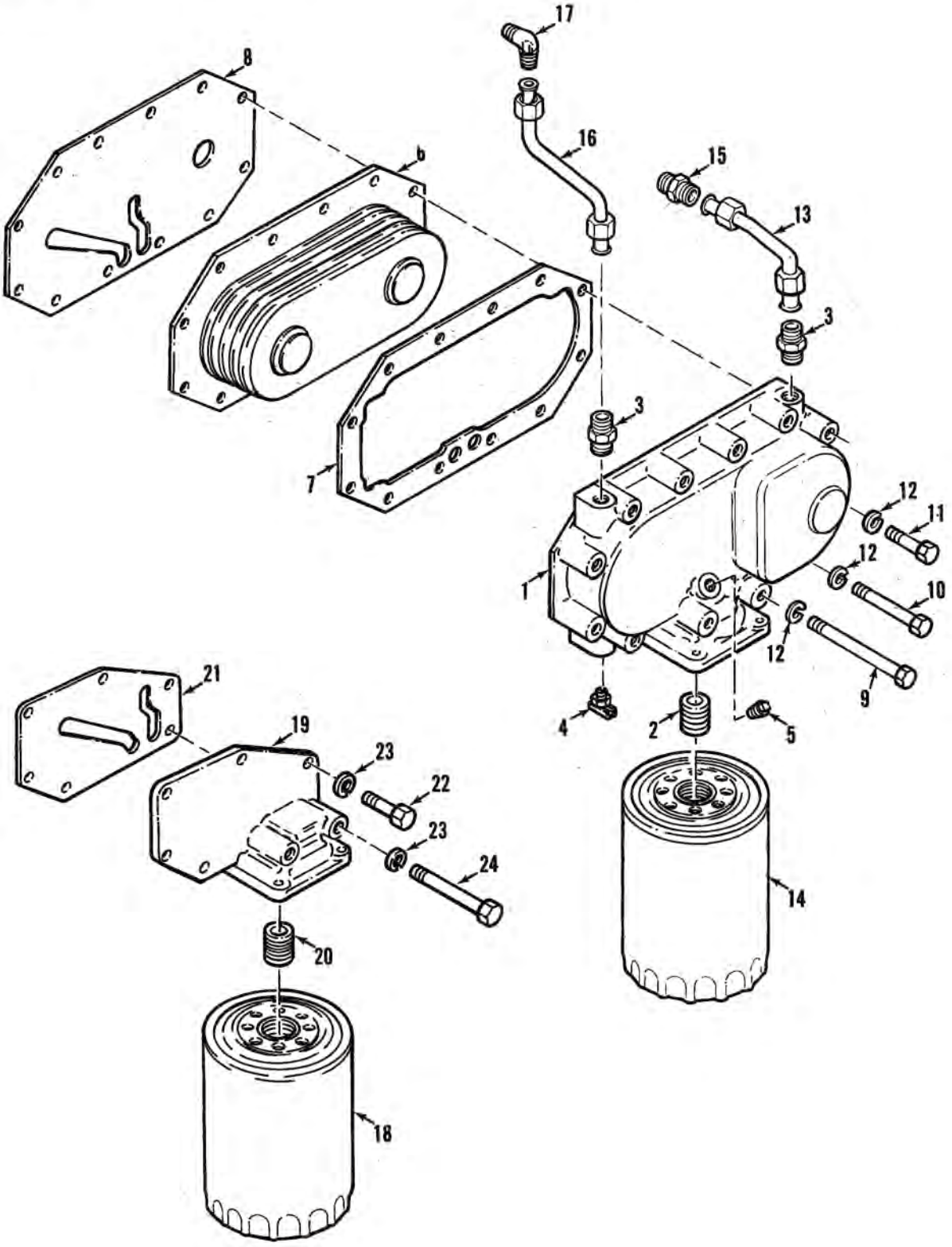

OIL FILTER, OIL COOLER

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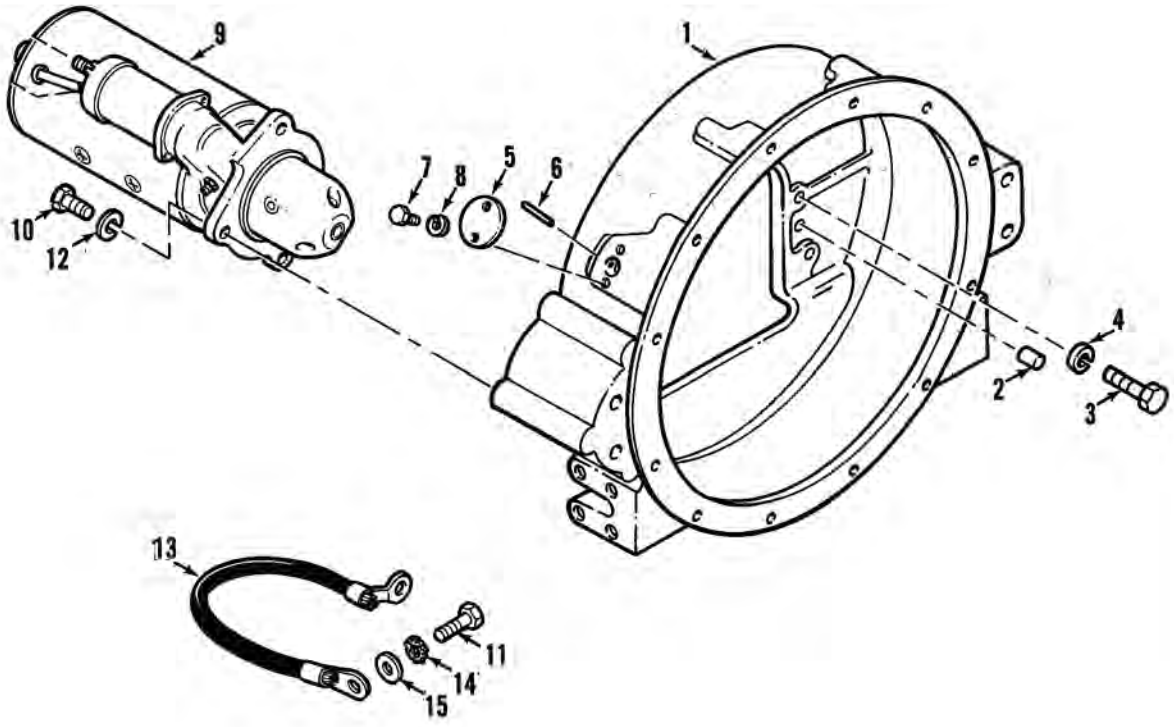
Oil Filter & Oil Cooler

Groups 17, 55

Item No.	Part Number	220	330	330 TA	330 CF	Description
	GROUP 17					
	A216055B	1	1		1	Cover, Oil Cooler - Assembly
	A216055B-T			1		
1	•216055B	1	1	1	1	Cover, Oil Cooler
2	•199983B	1	1		1	Adaptor, Lube Oil Filter Element
	•199983T			1		
3	•164717E	2	2	2	2	Connector, Flex
4	•73413A	1	1	1	1	Cock, Drain
5	•78282C	1	1		1	Plug, Pipe, Square Head, 1/4”
	•PF4-1/4			1		
6	208581	1	1	1	1	Element, Oil Cooler
7	208613	1	1	1	1	Gasket, Oil Cooler Cover
8	208614	1	1	1	1	Gasket, Oil Cooler
9	7A-3/816X31/2	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 3 1/2”
10	7A-3/816X21/2	9	9	9	9	Screw, Cap, Hex Head, 3/8” - 16 x 2 1/2”
11	21350	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16 x 1 1/8”
12	1A-3/8	12	12	12	12	Washer, Lock, 3/8”
13	AA208645A	1	1	1	1	Braided Hose, Water Inlet (New Style) Does Not Need Items 3 & 15
14	199982	1	1	1	1	Element, Oil Lube Filter
15	164717E	1	1	1	1	Connector, Flex
16	AA208645	1	1		1	Braided Hose, Water Inlet (New Style) Does Not Need Items 3 & 17
17	16724F	1	1		1	Elbow, Flex - Brass
	199111D			1		Elbow, Flex - Brass
	GROUP 55					
18	162709A	1	1	1	1	Element, Lube Oil Filter
	C216155	1	1	1	1	Base, Lube Oil Filter - Assembly (Less Oil Cooler)
19	•216155	1	1	1	1	Base, Lube Oil Filter, Small
	5105HW	1	1	1	1	Base, Lube Oil Filter, Larger
20	•199983B	1	1	1	1	Adaptor, Lube Oil Filter Element, Small
	199983T	1	1	1	1	Adaptor, Lube Oil Filter Element, Larger
	199983	1	1	1	1	Adaptor, Lube Oil Filter Element, Larger, Hex Head
	HW216255	1	1	1	1	Adaptor, Lube Oil Filter Element, Large
	208847	1	1	1	1	Adaptor, Lube Oil Filter Element, Remote Filter
21	208591	1	1	1	1	Gasket, Filter Base
	208848	1	1	1	1	Gasket, Filter Base, Remote Filter
	118013	1	1	1	1	O-Ring, Remote Filler
22	21350	5	5	5	5	Screw, Cap, Hex Head, 3/8” - 16 x 1 1/8”
	28651	4	4	4	4	Bolt, Remote Filter
23	1A-3/8	7	7	7	7	Washer, Lock, 3/8”
	1A-1/4	4	4	4	4	Washer, Lock
24	21369	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 3”

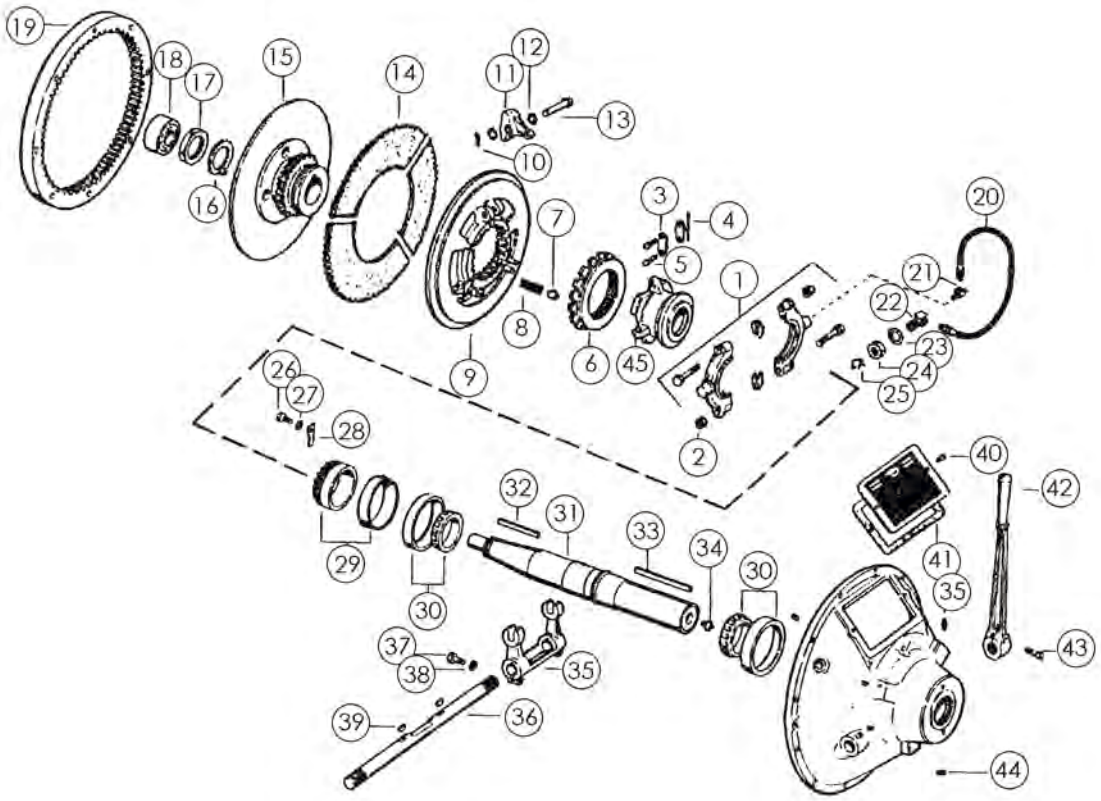


FLYWHEEL HOUSING, STARTER

Flywheel Housing, Starter

Groups 57, 204

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 57					
1	216057F	1	1	1	1	Housing, Flywheel
	MSP-675 MSP-3298	1	1	1	1	Speed Sensor
2	B9132	2	2	2	2	Pin, Dowel
3	21354	8	8	8	8	Screw, Cap, Hex Head, 3/8” - 16 x 1 3/8”
4	1A-3/8	8	8	8	8	Washer, Lock, 3/8”
5	B7042	1	1	1	1	Cover, Timing
6	28650	1	1	1	1	Pin, Roll, 5/64” x 1 1/2”
7	7A-1/420X5/8	2	2	2	2	Screw, Cap, Hex Head, 1/4” - 20 x 5/8”
	GROUP 204					
9	69754A	1	1	1	1	Starter (Standard)
	60963D	1	1	1	1	Heavy Duty Starter (Optional)
	69754B	1	1	1	1	24 Volt Starter (Optional)
10	7A-3/816X1	3	3	3	3	Screw, Cap, Hex Head, 3/8” - 16 x 1”
11	21350	1	1		1	Screw, Cap, Hex Head, 3/8” - 1 1/8” (Unit)
12	1A-3/8	3	3	3	3	Washer, Lock, 3/8”
13	O157776	1	1		1	Cable, Battery (Unit)
14	265653	1	1		1	Washer, External - Internal Shakeproof, 3/8” (Unit)
15	1N-3/8	1	1		1	Washer, Plain, 3/8” (Unit)
	X-7441-A	1	1	1	1	Handle, Clutch, For use with CO3 Actuator
	6625-A	1	1	1	1	Single Disc Drive Ring, 11”
	SP-111-HP-3	1	1	1	1	Single Disc Clutch, 11”, 2 1/4” Shaft
	X6931	1	1	1	1	Two Disc Drive Ring, 11”, 2 1/2” Shaft
	102540F	1	1	1	1	Two Disc Clutch, 11”



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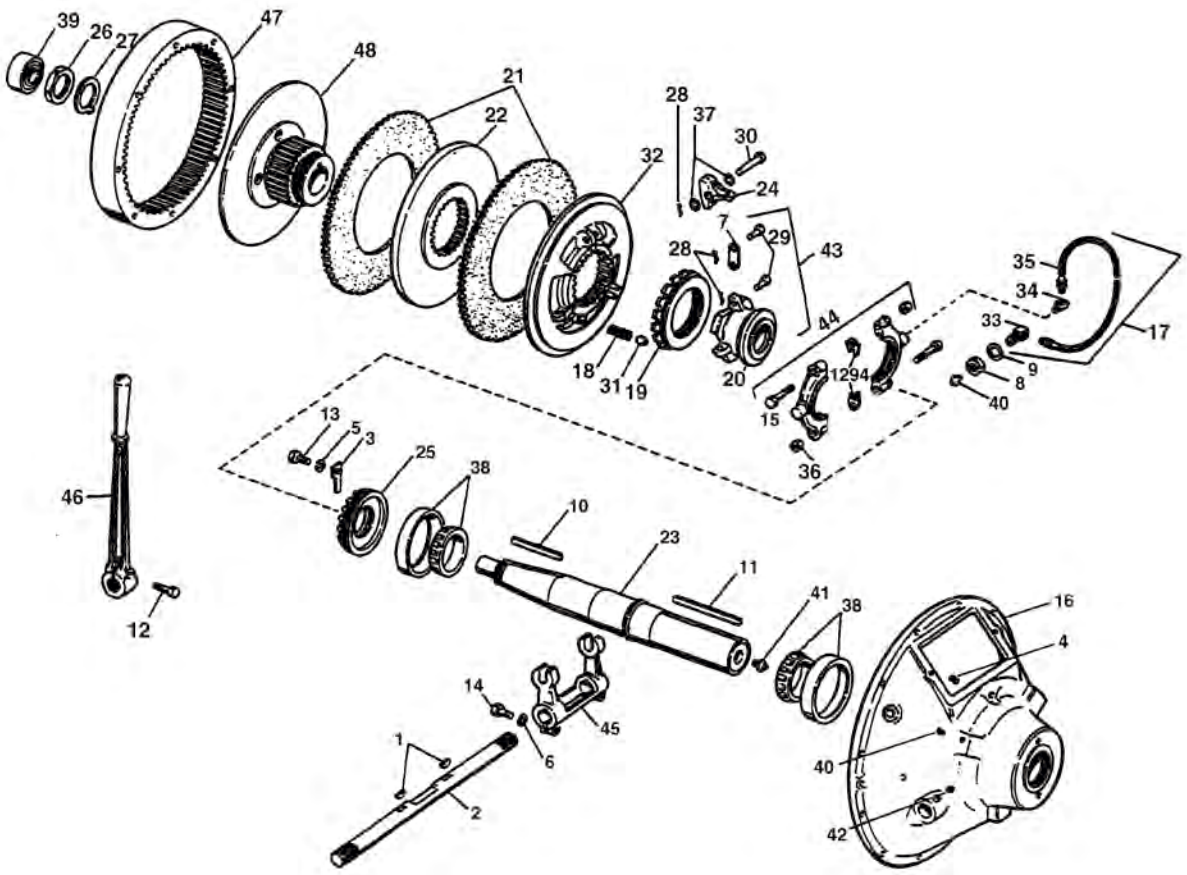
Single Plate Clutch

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	SP-111-HP-3	1	1	1	1	Clutch Assembly
1	•X-117	1	1	1	1	Collar Assembly
2	••32A-3/824	2	2	2	2	LockNut
3	••2617	1	1	1	1	Lever Link
4	••41A-3/32x5/8	8	8	8	8	Roll Pin
5	••B-1537-D	8	8	8	8	Lever Link Pin
6	•A-4238	1	1	1	1	Adjusting Ring
7	•B-1272	1	1	1	1	Adjusting Lock Pin
8	•115	1	1	1	1	10” Adjusting Lock Spring
9	•XB-2343	1	1	1	1	Floating Plate
10	•2B-5/32x1/2	4	4	4	4	Tee Head Cotter Pin
11	•B-1304	3	3	3	3	Finger Lever
12	•M-2115-D	8	8	8	8	Spring Washer
13	•B-1538-A	3	3	3	3	Finger Lever Pin
14	•A-5579-E	1	1	1	1	3 Piece Drive Plate
15	ZA-6505-A	1	1	1	1	Hub, Back Plate Assembly
16	A-1588	1	1	1	1	Lockwasher
17	1092	1	1	1	1	Hub Nut
18	M-167	1	1	1	1	10” Pilot Bearing
19	6625-A	1	1	1	1	Drive Ring
	A-1663-A	1	1	1	1	11” Hose Assembly
20	•M-1292-B	1	1	1	1	Flex Hose
21	•M-1284	1	1	1	1	7, 8, 10” Fitting
22	•M-1283	1	1	1	1	7, 8, 10” Fitting
23	•2C-5/8	1	1	1	1	Internal Lockwasher
24	29D-5/818	1	1	1	1	Jam Nut Finished Hex
25	M-268	2	2	2	2	Lube Fitting-Male
26	7A-5/1618x5/8	1	1	1	1	Capscrew, Hex Head
27	2C-5/16	1	1	1	1	Internal Lockwasher
28	1216-A	1	1	1	1	Bearing Retainer Shaft
29	B-2147	1	1	1	1	10” Bearing Spacer
30	M-207	1	1	1	1	10” Clutch Bearing
31	A-5188	1	1	1	1	11” Clutch Shaft
32	6A-3/8x3/8x21/2	1	1	1	1	Key, Square Ends
33	6A-5/8x5/8x53/8	1	1	1	1	Key, Square Ends
34	M-287	1	1	1	1	7, 8, 10” Shaft Fitting
35	X-125-A	1	1	1	1	Throwout Yoke
36	1144-E	1	1	1	1	Operating Shaft
37	7A-3/816x11/2	2	2	2	2	Capscrew, Hex Head
38	2C-3/8	2	2	2	2	Internal Lockwasher
39	104A-#15	2	2	2	2	Woodruff Key
40	12A-1/420x1/2	2	2	2	2	Machine Screw, Round Head
41	ANP-22-A	1	1	1	1	Spec. Plate
42	X-3799	1	1	1	1	7, 8, 10” Hand Lever
43	7A-1/213x13/4	1	1	1	1	Capscrew, Hex Head
44	M-503	1	1	1	1	Grease Fitting Shaft
45	*S-601	1	1	1	1	Sleeve



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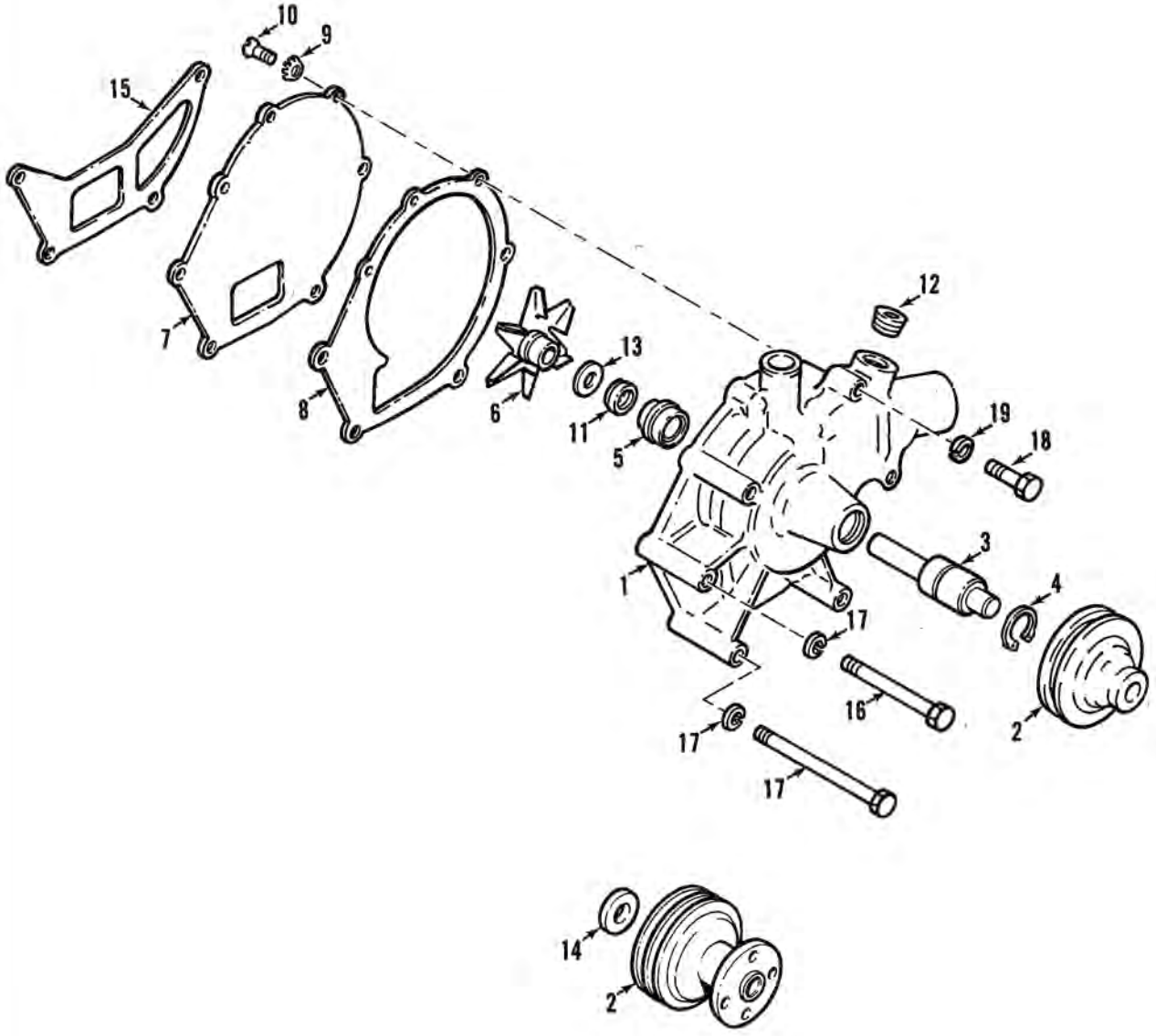
Double Plate Clutch

Item No.	Part Number	220	330	330 TA	330 CF	Description
	102540F	1	1	1	1	Doublr Plate Clutch
1	104A-#15	2	2	2	2	Woodruff Key
2	1144-F	1	1	1	1	10” Operating Shaft
3	1216	1	1	1	1	Bearing Retainer Lock
4	12A-1/420x1/2	2	2	2	2	Round Head Screw
5	1A-1/4	1	1	1	1	Lock Washer
6	1A-3/8	2	2	2	2	Lock Washer
7	2617	6	6	6	6	Lever Link
8	29D-5/818	1	1	1	1	Jam Nut
9	2C-5/8	1	1	1	1	Lock Washer
10	6A-3/8x7/8x21/2	1	1	1	1	Key
11	6A-5/8x5/8x53/8	1	1	1	1	Key
12	7A-1/213x13/4	1	1	1	1	Hex Headed Cap Screw $^{1}/_{2}$ - 13 x $1^{3}/_{4}$
13	7A-1/420x5/8	1	1	1	1	Hex Headed Cap Screw $^{1}/_{4}$ - 20 x $^{5}/_{8}$
14	7A-3/816x11/2	2	2	2	2	Hex Headed Cap Screw $^{3}/_{8}$ - 16 x $1^{1}/_{2}$
15	7A-3/824x21/4	2	2	2	2	Hex Headed Cap Screw $^{3}/_{8}$ - 24 x $2^{1}/_{4}$
16	9682	1	1	1	1	Housing #2 SAE
	9977-A	1	1	1	1	Housing #3 SAE NLA
17	A-1663-A	1	1	1	1	Hose Assembly
18	A-2702-BE	1	1	1	1	Spring (Obsolete)
19	A-4238	1	1	1	1	Adjusting Ring - C-106
20	A-4422	1	1	1	1	Sliding Sleeve (Obsolete)
21	A-5579-E	2	2	2	2	11” Driving Plate, 3 Piece
22	A-6690					Center Plate
23	A-6691-AC	1	1	1	1	Clutch Shaft with Keys
	ANP-22-A	1	1	1	1	Instruction Cover Plate
24	B-1304	3	3	3	3	Finger Lever
25	B-1430	1	1	1	1	Bearing Retainer
26	B-1509-B	1	1	1	1	Hub Nut
27	B-1511-E	1	1	1	1	Lock Washer (Obsolete)
28	B-1537-B	3	3	3	3	Cotter Pin
29	B-1537-D	6	6	6	6	Lever Pin
30	B-1538-A	3	3	3	3	Lever Pin
31	B-2341	1	1	1	1	Adjusting Block Pin
32	HTA-6506-B	1	1	1	1	Floating Plate (Obsolete)
33	M-1283	1	1	1	1	Fitting
34	M-1284	1	1	1	1	Fitting
35	M-1292-B	1	1	1	1	14” Flexible Hose
36	M-1930-F	2	2	2	2	Hex Nut
37	M-2115-C	6	6	6	6	Spring Washer
38	M-2196	1	1	1	1	Roller Bearing
39	M-224-A	1	1	1	1	Pilot Bearing
40	M-268	2	2	2	2	Fitting
41	M-287	1	1	1	1	Shaft Fitting
42	M-503	1	1	1	1	Fitting
43	S-634	1	1	1	1	Sliding Sleeve Assembly
44	X-117-C-10	1	1	1	1	Collar Assembly
45	X-3507	1	1	1	1	Throwout Yoke
46	X-3799E	1	1	1	1	Hand Lever
47	X6931	1	1	1	1	Driving (or Spider) Ring
48	ZA-6684-A	1	1	1	1	Hub-and-Back Plate



WATER PUMP

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Water Pump
Group 60

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	D216160C	1	1	1	1	Pump, Water - Assembly (Bracket Mounted Fan)
	D216160C-A54	1	1	1	1	Pump, Water - Assembly (Water Pump Mounted Fan)
1	•216160C	1	1	1	1	Body, Water Pump
2	•208559A	1	1	1	1	Pulley, Water Pump (Bracket Mounted Fan)
	•216194A	1	1	1	1	Pulley, Water Pump (Water Pump Mounted Fan)
3	•208621C	1	1	1	1	Shaft/Bearing, Water Pump
4	•44999R	1	1	1	1	Ring, Retaining
5	•120320E	1	1	1	1	Seal, Water Pump
	•120320MT	1	1	1	1	Tool for Unitized Mechanical Seal 120320M
6	•220163	1	1	1	1	Impeller, Water Pump
7	•216061	1	1	1	1	Cover, Water Pump
8	•208625A	1	1	1	1	Gasket, Water Pump Cover
9	•21842	3	3	3	3	Washer, External Shakeproof, 1/4”
10	•28654	3	3	3	3	Screw, Flat Head, 1/4” - 20 x 7/16”
11	•161647B	1	1	1	1	Seat, Water Pump Seal
12	•78283J	1	1	1	1	Plug, Pipe, Contersunk Headless - Plated, 1/2”
13	•211345	1	1	1	1	Spacer, Impeller
14	•153312A	1	1	1	1	Seal, Dust (Water Pump Mounted Fan)
15	•208624	1	1	1	1	Gasket, Water Pump
	•494419	1	1	1	1	Instructions
16	21370	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 3 1/4” (Bracket Mounted Fan)
	7A-3/816X21/4	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 2 1/4” (Water Pump Mounted Fan)
17	7A-3/816X31/2	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 3 1/2” (Bracket Mounted Fan)
	21369	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 3” (Water Pump Mounted Fan)
18	7A-3/816X1	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 1” (Bracket Mounted Fan)
19	1A-3/8	6	6	6	6	Washer, Lock, 3/8” (Bracket Mounted Fan)
	1A-3/8	4	4	4	4	Washer, Lock, 3/8” (Water Pump Mounted Fan)
	KITS					
	960-254	1	1	1	1	Water Pump Repair Kit (Water Pump Assembly D216060A) Includes Items 3, 5, 6, 8-11, 13, 15)
	960-255	1	1	1	1	Water Pump Repair Kit (Water Pump Assembly D216160B) Includes Items 3, 5, 6, 8-11, 13-15

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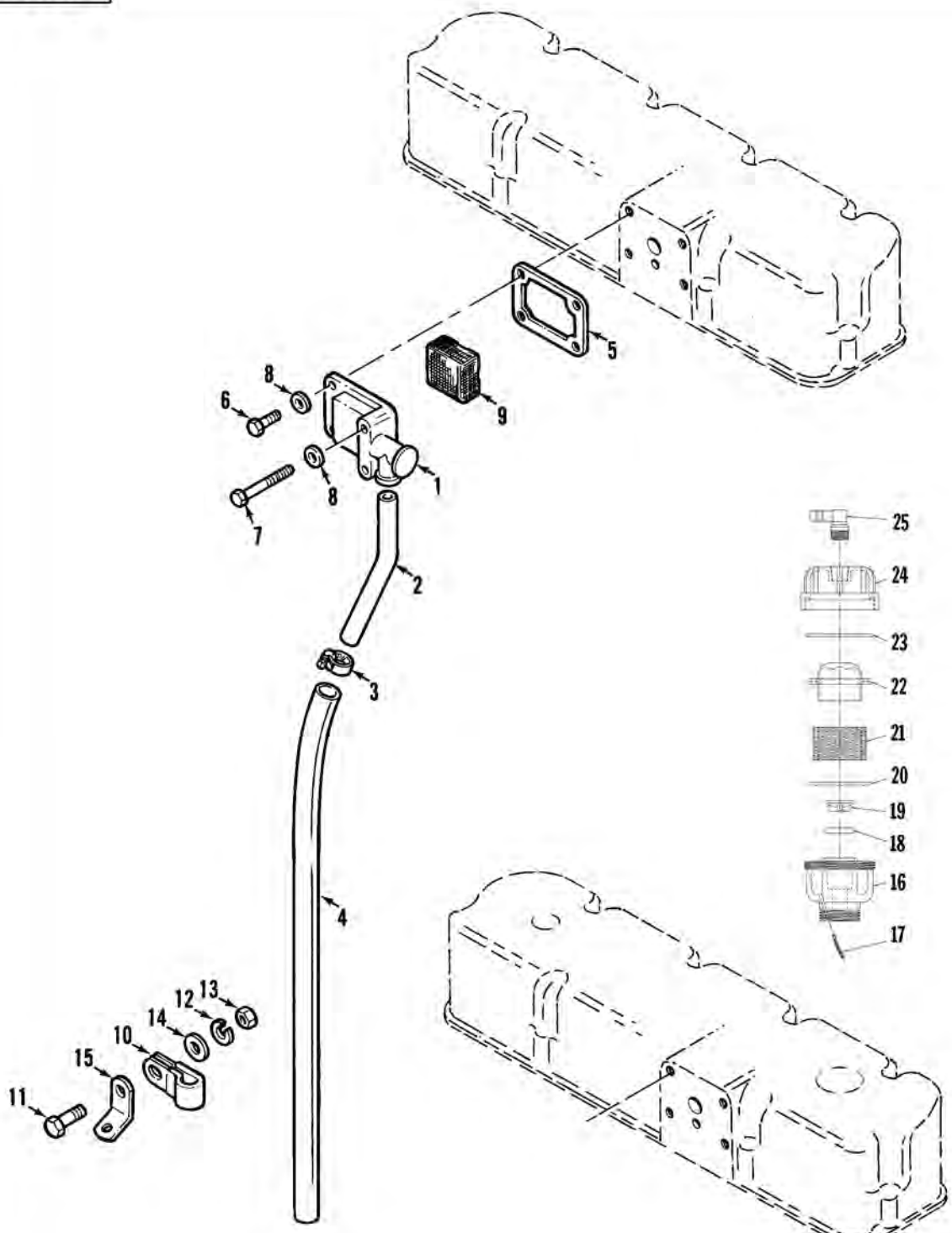

BREATHER

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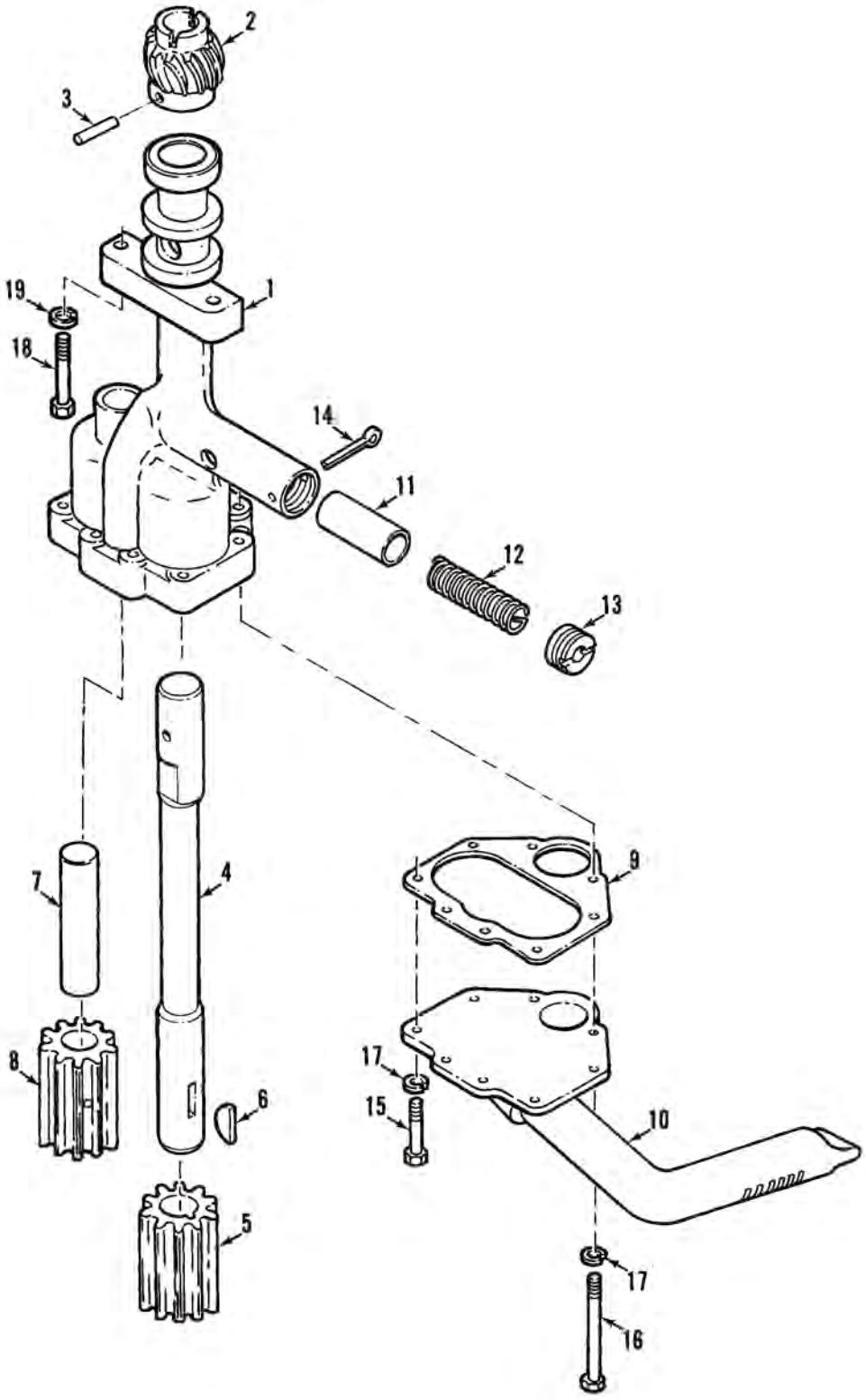
Breather
Group 70

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	E164822C	1	1	1	1	Flange, Breather - Assembly
1	•164822C	1	1	1	1	Flange, Breather
2	•209749J	1	1	1	1	Tube, Breather
3	•118224	1	1	1	1	Clamp, Hose
4	•157800G	1	1	1	1	Hose
5	199412A	1	1	1	1	Gasket, Breather Flange
6	28651	2	2	2	2	Screw, Cap, Hex Head, Nylok, 1/4” - 20 x 7/8”
7	28652	2	2	2	2	Screw, Cap, Hex Head, Nylok, 1/4” - 20 x 1 3/4”
8	1N-1/4	4	4	4	4	Washer, Plain, 1/4”
9	168191B	1	1	1	1	Element, Breather
10	177487L	1	1	1	1	Clip, Tube
11	7A-3/816X1	1	1	1	1	Screw, Cap, Hex Head, 3/8” - 16 x 1”
12	1A-3/8	1	1	1	1	Washer, Lock, 3/8”
13	29A-3/816	1	1	1	1	Nut, Hex, 3/8” - 16
14	1N-3/8	1	1	1	1	Washer, Plain, 3/8”
15	209561M	1	1	1	1	Support, Clip
16	244-BCP	1	1	1	1	Valve Cover Breather Assembly
	244-GROM	1	1	1	1	Rubber Grommet
	244-PCV	1	1	1	1	PCV Valve
	7/16 Rubber Hos	1	1	1	1	6’ Rubber Hose
	7/16 Rubber Hos	1	1	1	1	2’ Rubber Hose

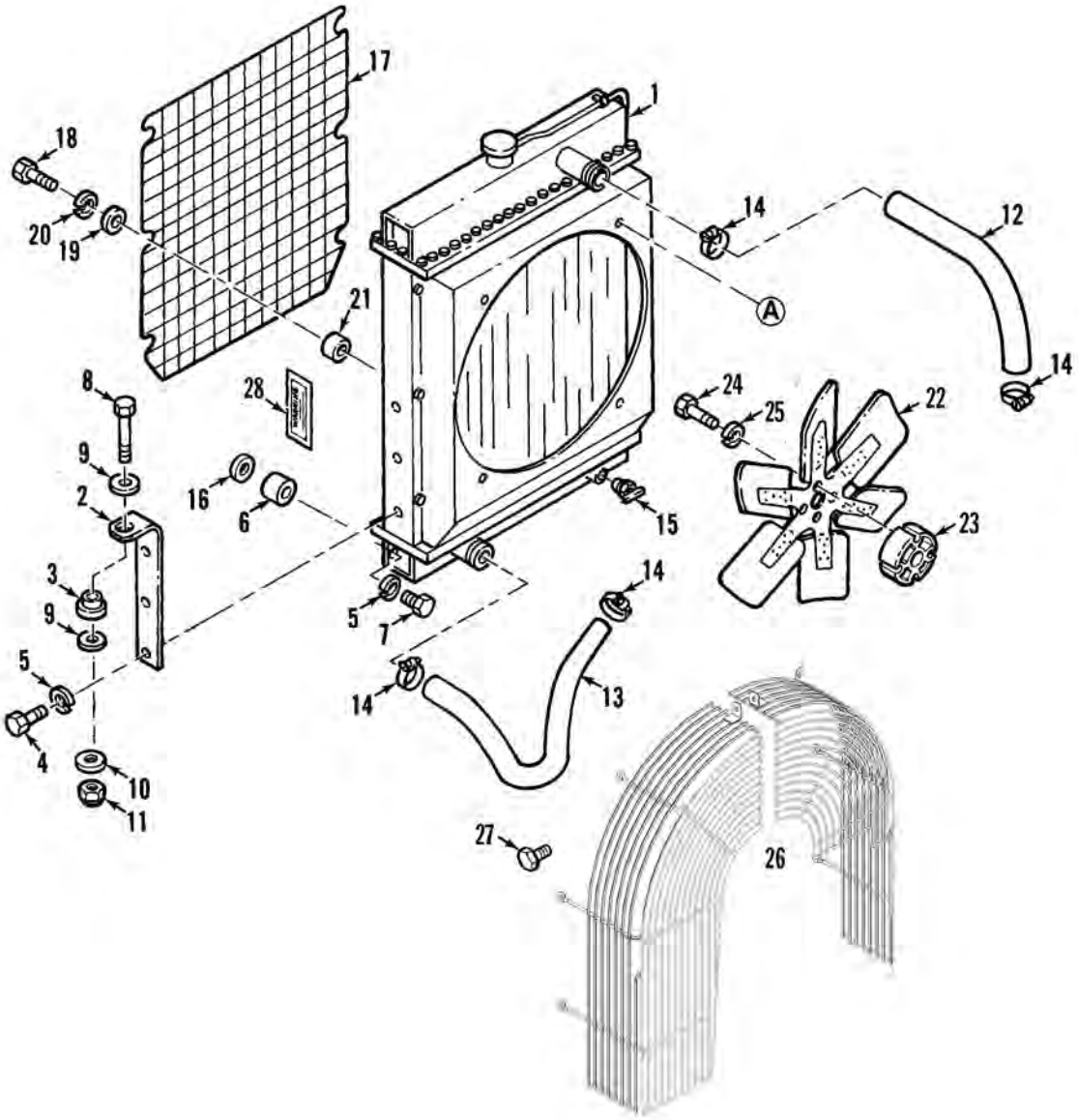


OIL PUMP

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Oil Pump
Group 80

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	D216080C					Pump, Oil - Assembly (With Shallow Rear Sump Oil Pan)
	A216080C	1				Pump, Oil - Assembly (With Deep Rear Sump Oil Pan)
	C216080C		1	1	1	Pump, Oil - Assembly (With Deep Rear Sump Oil Pan)
	E216080C					Pump, Oil - Assembly (With Front Sump Oil Pan)
1	•216080C	1	1	1	1	Body, Oil Pump
2	•216051A	1	1	1	1	Gear, Oil Pump Drive
3	•26583	1	1	1	1	Pin, Roll, 3/16” x 1 1/4”
	•A216084A	1	1	1	1	Shaft, Oil Pump Drive - Assembly
4	••216084A	1	1	1	1	Shaft, Oil Pump Drive
5	••216081A	1	1	1	1	Gear, Oil Pump - Driven
6	••104A-#5	1	1	1	1	Key, Woodruff, No. 5
7	•216083	1	1	1	1	Shaft, Oil Pump Idler Gear
8	•216085	1	1	1	1	Gear, Oil Pump - Idler
9	•208562	1	1	1	1	Gasket, Oil Pump Cover
10	•D216182					Cover, Oil Pump (With D216080C Pump)
	•A216182A	1				Cover, Oil Pump (With A216080C Pump)
	••C216182A		1	1	1	Cover, Oil Pump (With C216080C Pump)
	•A216182	1				Cover, Oil Pump (With E216080C Pump)
	••28641	1				Plug, Pipe, Allen Head, 3/4”
11	•208580A	1	1	1	1	Plunger, Relief Valve
12	•208565	1	1	1	1	Spring, Relief Valve
13	•208588	1	1	1	1	Screw, Relief Valve Adjusting
14	•2A-1/8X13/4	1	1	1	1	Pin, Cotter, 1/8” x 1 3/4”
15	•7A-1/420X1	6	6	6	6	Screw, Cap, Hex Head, 1/4” - 20 x 1”
16	•21291	2	2	2	2	Screw, Cap, Hex Head, 1/4” - 20 x 2”
17	•1A-1/4	8	8	8	8	Washer, Lock, 1/4”
18	•21354	2	2	2	2	Screw, Cap, Hex Head, 3/8” - 16 x 1 3/8”
19	•1A-3/8	2	2	2	2	Washer, Lock, 3/8”
	KITS980-153					
	980-153	1	1	1	1	Oil Pump Repair Kit (Oil Pump Assembly 216080C) Includes Items 2-9, 11-14



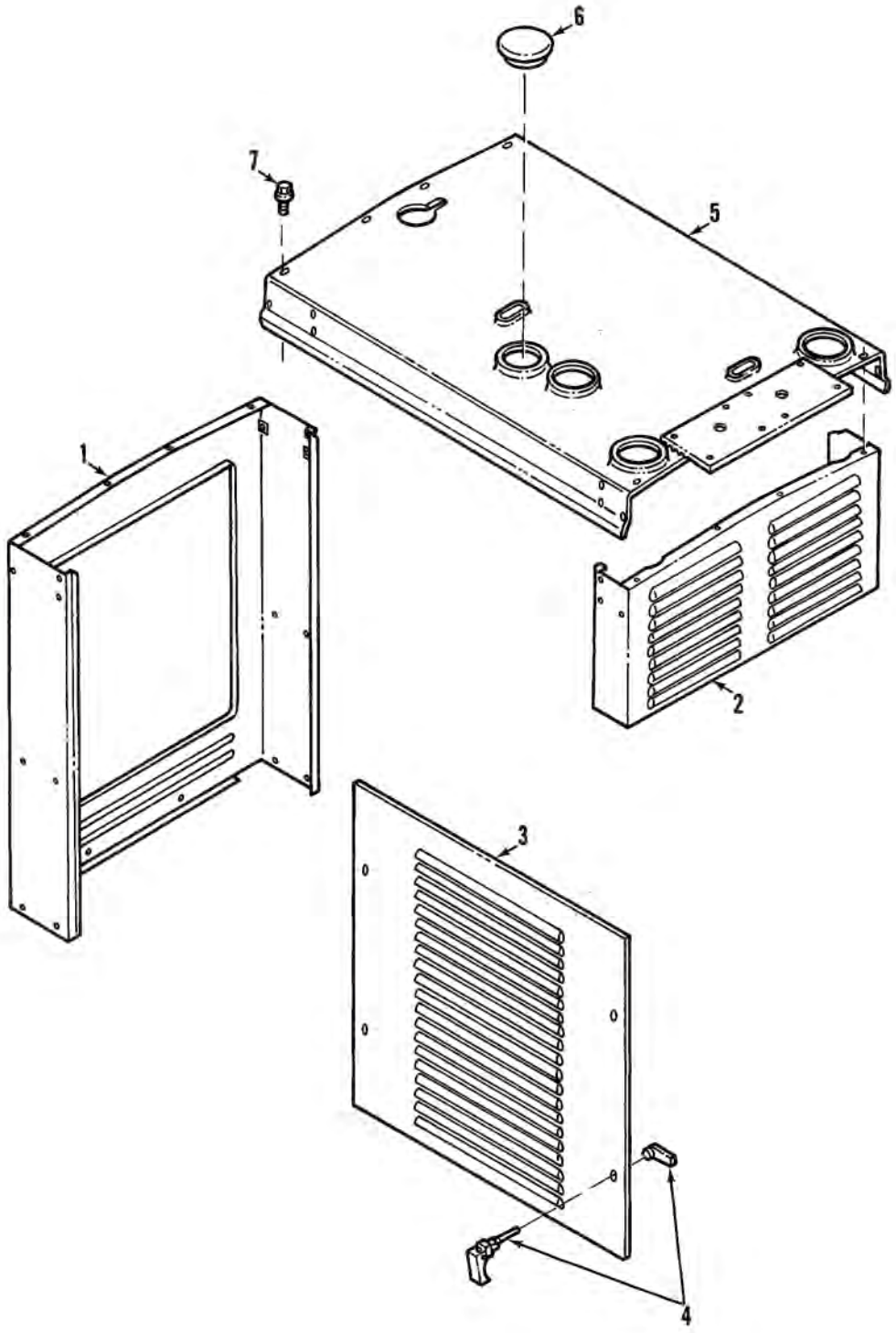
RADIATOR, SAFETY GUARDS

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Radiator, Safety Guards

Group 200

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	208771 CSE	1	1		1	Radiator, Soldered
	208771C	1	1	1	1	Radiator, Bolted
	208771G	1	1		1	Gasket for Top Tank
2	•208738	2	2	2	2	Strap, Radiator Support
3	•208313	2	2	2	2	Mount, Center Bonded
4	7A-5/1618X3/4	6	6	1	6	Screw, Cap, Hex Head, 5/16” - 18 x 3/4”
5	1A-5/16	10	10	10	10	Washer, Lock, 5/16”
6	119058	2	2	2	2	Mount, Vibration
7	7A-5/1618X1/2	4	4	6	4	Screw, Cap, Hex Head, 5/16” - 18 x 1/2” (Soldered Radiator)
	7A-5/1618X7/8	2	2	2	2	Screw, Cap, Hex Head, 5/16” - 18 x 7/8” (Bolted Radiator)
8	21437	2	2	2	2	Screw, Cap, Hex Head, 1/2” - 13 x 2 1/4”
9	B8568A	4	4	4	4	Washer, Plain, 1/2”
10	1N-1/2	2	2	2	2	Washer, Plain, 1/2”
11	119537	2	2	2	2	Nut, Lock-Eleastic Stop, 1/2” - 13
12	208773	1	1	1	1	Connection, Hose - Upper
13	208774	1	1	1	1	Connection, Hose - Lower
14	41236C	4	4	4	4	Clamp, Hose
15	76400	1	1	1	1	Cock, Drain
16	117428	2	2	2	2	Spacer (Bolted Radiator)
17	208750	1	1		1	Guard, Radiator Core
18	26249	6	6		6	Screw, Cap, Hex Head, 5/16” - 18 x 1/2”
19	159447C	6	6		6	Washer, Plain, 11/32”
20	1A-5/16	24	24		24	Washer, Lock, 5/16”
21	80139B	6	6		6	Spacer
22	209027	1	1		1	Blade, Fan (20” Suction)
	209026	1	1		1	Blade, Fan (20” Pusher)
23	207973					Spacer, Fan Blade, 2 15/32”
	207973A					Spacer, Fan Blade, 1 17/32”
	207973H					Spacer, Fan Blade, .978”
	208747LI-A54		2			Rubber Grommet, for A54
	208747L-A54		1			Support, Radiator, for A54
24	7A-5/1618X2	4	4		4	Screw, Cap, Hex Head, 5/16” - 18 x 2”
25	1A-5/16	11	11		11	Washer, Lock, 5/16”
26	A208926B	1	1		1	Guard, Fan Assembly, 2 Piece
	A208926B-A54		1			Guard, Fan Assembly, for A54
27	28470	7	7		7	Screw, Cap, Hex Head, 5/16” - 18 x 5/8”
28	209107D	2	2		2	Tag, Warning
	207945			1		Cap, Radiator, Heavy
	OL-E-96			1		Water Guage and Fill
	48x5x4			2		Connector, Straight
	208776			1		Radiator Hose
	ANP-11			1		Nameplate, Water Level
	ANP-14			1		Decal, Caution - Press Cooling
	7A-5/1618x1			2		Capscrew, Hex Head
	1N-5/16			2		Washer, Flat
	Y18802			1		Plug, Pipe 1/8 NPT Flush Type

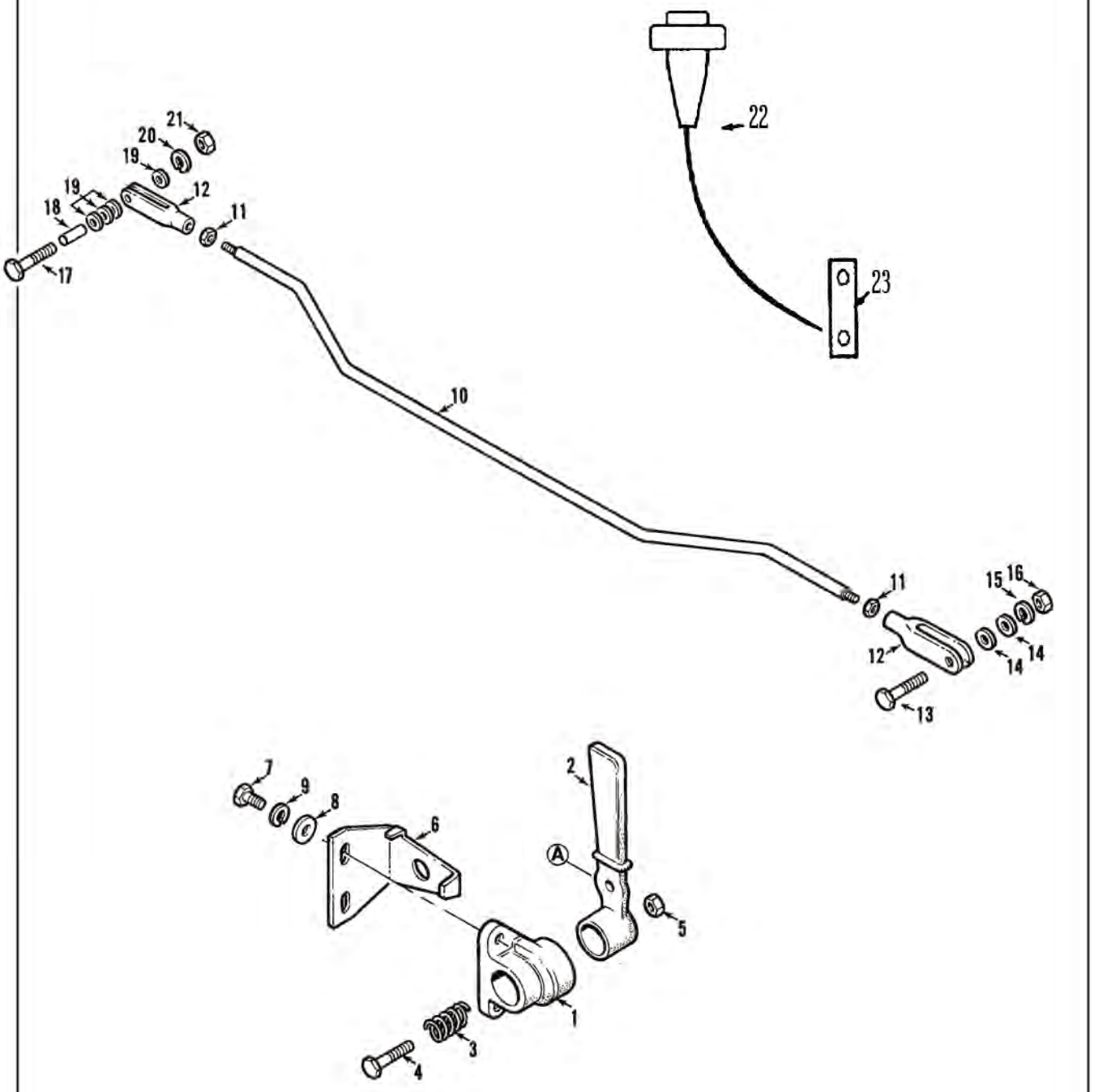


SHEET METAL (Closed Unit)

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Sheet Metal
Group 201

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	A208749	1	1		1	Shell, Radiator
2	A208754	1	1		1	Panel, Upper Rear
3	A208751	2				Door, Side
	A208752		2		2	
4	208772	8	8		8	Latch, Grip
5	A208777	1				Hood, Unit
	A208778		1		1	
6	208854	2	2		2	Plug, Hole
7	28470	36	36		36	Screw, Cap, Hex Head, 5/16” - 18 x 5/8”



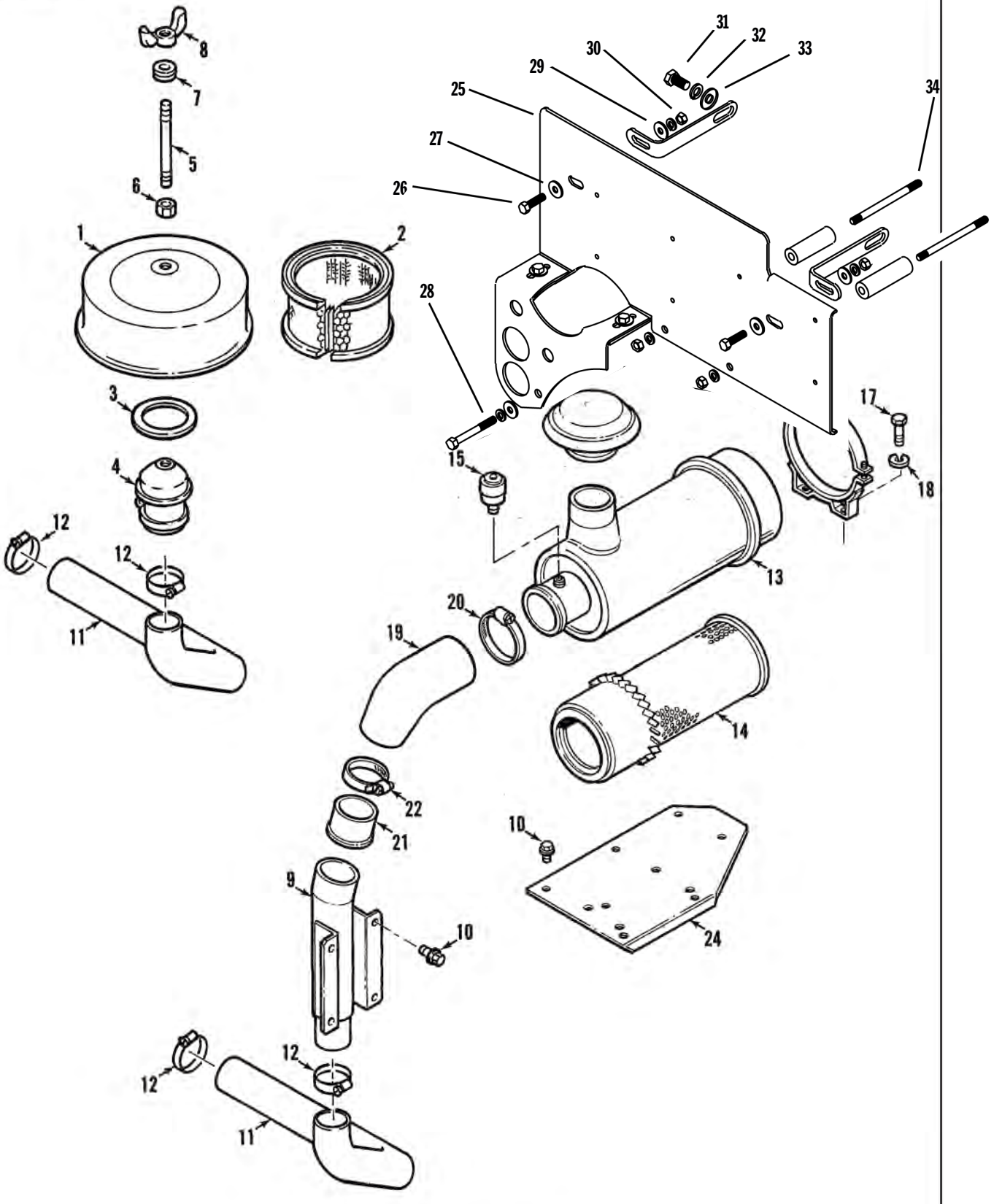
THROTTLE CONTROL

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Throttle Control
Group 203

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	ROD STYLE					
	0B9266	1	1			Lever, Throttle
1	•B9266	1	1			Bracket
2	•B9267	1	1			Lever, Throttle
3	•B9269	1	1			Spring
4	•7A-3/816X21/4	1	1			Screw, Cap, Hex Head, 3/8” - 16 x 2 1/4”
5	•29D-3/816	1	1			Nut, Hex, 3/8” - 16
6	207915	1	1			Stop, Throttle Lever
7	7A-3/816X7/8	2	2			Screw, Cap, Hex Head, 3/8” - 16 x 7/8”
8	1N-3/8	2	2			Washer, Plain, 3/8”
9	1A-3/8	2	2			Washer, Lock, 3/8”
	A208650-NS	1	1			Rod, Control - Assembly
10	•208650-NS	1	1			Throttle Control
11	•29A-1/428	2	2			Nut, Thin Hex, 1/4” - 28
12	•312-106A	2	2			Rod End
13	*7A-1/420x1	1	1	1		Capscrew, Hex Head
14	*73448	3	3	3		Washer, Plain
15	*1A-1/4	1	1	1		Lockwasher, Plated
16	*27A-1/420	1	1	1		Nut, Hex, Jam Heavy
17	*12E-1024x11/4	1	1	1		Screw, Fillister Machine
18	*208650T	1	1	1		Tubing for 208650-NS
19	*93-A-464	4	4	4		Washer, #8, Flat
20	*1A-#10	1	1	1		Lockwasher, Plated
21	*30A-1024	1	1	1		Nut, Machine Screw
	CABLE STYLE					
	6301-2	1				Cable Assembly
	6301-3		1		1	
22	208851	1	1		1	Throttle Cable
23	208870B	1	1		1	Bracket Cable to Carburetor
	208851-1	1	1		1	Bushing for Governor Arm
	208851-2	1	1		1	Nut, Wire Stop with Screw
	208851-3	1	1		1	Cable Cover Field Kit

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

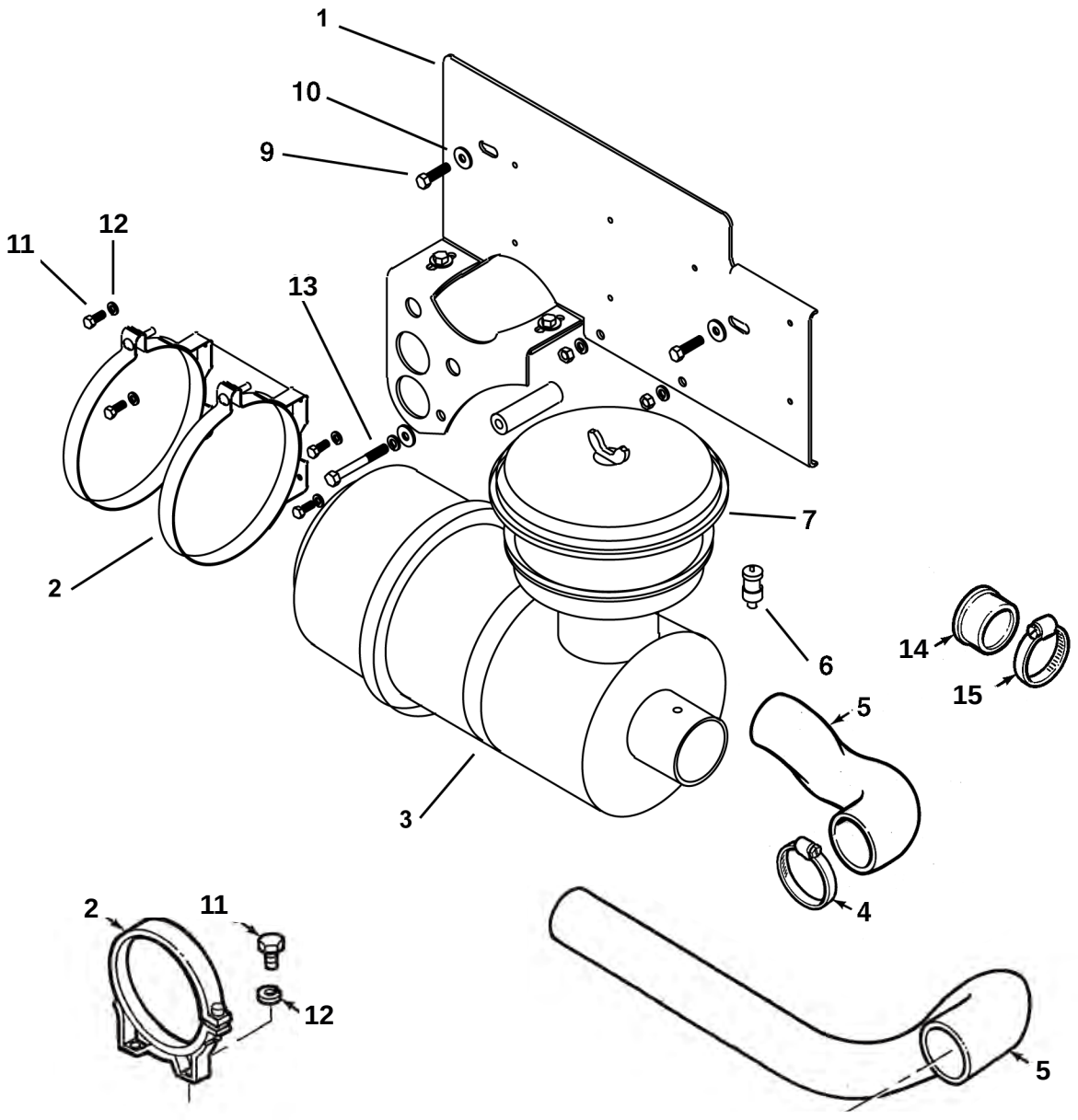


AIR CLEANERS

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Air Cleaners
Group 208

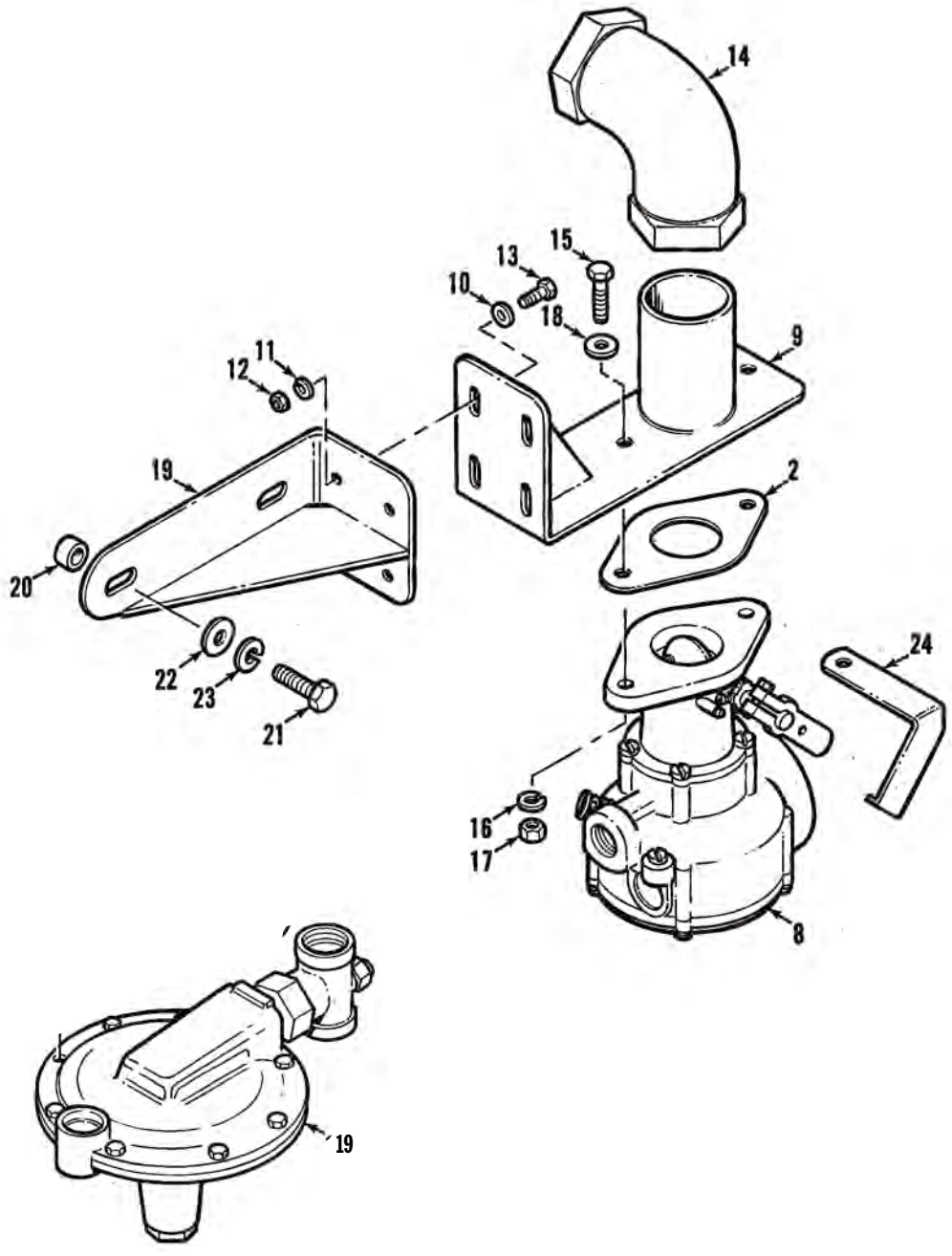
Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	2325	1	1			Air Cleaner with Precleaner Assembly
	2325T			1		
1	209349A	1	1	1		Pre-Cleaner - Assembly
2	•208300	1	1			Element, Air Cleaner
3	208297	1				Gasket, Air Cleaner
4	208775		1			Fitting, Air Cleaner
5	208845	1	1			Stud
	208845A	1	1			
6	21175	1	1			Nut, Thin Hex, 1/4” - 20
7	208401	1	1			Washer/Seal
8	208298	1	1			Nut, Wing
9	28575			1		Elbow, Conn. Air Inlet
10	28470	4	4	4		Screw, Cap, Locking Hex Head, 5/16” - 18 x 5/8” (Closed Unit)
11	208779A					Connection, Hose, Lower Air Intake
	208779	1	1			Connection, Hose, Lower Air Intake, 4 3/4”
12	41236D	2	2			Clamp, Hose
13	199421A	1	1	1		Cleaner, Air (Circular Type)
14	•208227A	1				Element, Air Cleaner Length, 15 1/2”, Diameter 6”
	•208227		1	1		Element, Air Cleaner Length,16 1 /2”, Diameter 6 3/4”
15	153789	1	1	1		Indicator, Air Restrictor
16	152802	2		2		Band, Mounting
	118974		2			
17	7A-5/1618x11/2	4				Screw, Cap, Hex Head, 5/16” - 18 x 1 1/2” (Open Unit)
	7A-5/1618X5/8	4		4		Screw, Cap, Hex Head, 5/16” - 18 x 5/8” (Closed Unit)
	7A-3/816X7/8		4			Screw, Cap, Hex Head, 3/8” - 16 x 7/8” (Open Unit)
	7A-3/816X3/4		4			Screw, Cap, Hex Head, 3/8” - 16 x 3/4” (Closed Unit)
18	1A-5/16	4		4		Washer, Lock, 5/16”
	1A-3/8		4			Washer, Lock, 3/8”
19	208860	1		1		Connection, Hose, Air Intake (Open or Closed Unit)
	208861A		1			Connection, Hose, Air Intake (Closed Unit)
20	41236	1		1		Clamp, Hose
	41236B		1			
21	208853	1	1	1		Adaptor, Rubber
	208858B	2	2	1		
22	41236A	1	1	1		Clamp, Hose
23	199432A	1				Cap, Air Inlet
	199432		1	1		
24	208859	1	1	1		Plate, Support (Open Unit)
25	208843	1	1			Mounting Panel
	208843-TA			1		
26	7A-3/816X7/8	2	2			Screw, Cap, Hex Head, 3/8” - 16 x 7/8”
27	1A-3/8	9	9			Washer, Lock, 3/8”
28	7A-3/816X3	1	1			Screw, Cap, Hex Head, 3/8 - 16 x 3”
29	1B-318	9	9			Washer, Flat, 3/8”
30	27A-31816	8	8			Nut, Hex Head, 3/8” - 16
31	7A-1/213x1	1	1			Screw, Cap, Hex Head, 1/2” - 13 x 1”
32	1A-1/2	1	1			Washer, Lock, 1/2”
33	1B-1/2	1	1			Washer, Flat, 1/2”
34	5-96	2	2			Stud



•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Air Cleaners, Crossflow
Group 209

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	2325-CF				1	Air Cleaner with Precleaner Assembly
1	208843-TA				1	Panel, Turbo Unit Front
2	152802				2	Band, Mounting
	118974				2	Band, Mounting, Power Unit
3	199421				1	Clear, Air, Small - Assembly
4	41236B				1	Clamp, Hose
5	208779-CF				1	Connection Hose, Lower Air Intake
	208876				1	Connection Hose, Lower Air Intake, Power Unit
6	153789				1	Indicator, Restriction
	153789A				1	Indicator, Restriction, Power Unit
7	209349A				1	Pre-Cleaner
	199432				1	Pre-Cleaner, Power Unit
8	5-96				2	Stud
9	7A-3/816X7/8				2	Screw, Cap, Hex Head, 3/8” - 16 x 7/8”
10	1A-3/8				9	Washer, Lock, 3/8”
11	7A-5/1618X5/8				4	Screw, Cap, Hex Head, 5/16” - 18 x 5/8”
	7A-3/816X3/4				4	Screw, Cap, Hex Head, 3/8” - 16 x 3/4”, Power Unit
12	1A-5/16				4	Washer, Lock, 5/16”
	1A-3/8				4	Washer, Lock, 3/8”, Power Unit
13	7A-3/816X3				1	Screw, Cap, Hex Head, 3/8 - 16 x 3”
14	208853				1	Adaptor, Rubber
15	41236A				1	Clamp, Hose
	208227				1	Elememt, Air Cleaner



CARBURETOR

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
8	199097A	1	1		1	Carburetor, Natural Gas
	•499220	1	1		1	Valve, Air/Gas - Assembly
	••498925	1	1		1	Diaphragm, Air/Gas Valve
	AT2-4-1	1	1		1	Body, Throttle
	ALI-33	1	1		1	Lever
2	B1331F	1	1			Gasket, Carburetor
9	211043A	1	1		1	Bracket, Carburetor
10	B277	4	4		4	Washer, Plain, 5/16”
11	1A-5/16	4	4		4	Washer, Lock, 5/16”
12	29A-5/1618	4	4		4	Nut, Hex, 5/16” - 18
13	7A-8/1618X1	4	4		4	Screw, Cap, Hex Head, 3/8” - 18 x 1”
14	161592E	1	1		1	Elbow, Dresser
15	7A-3/816X13/4	2	2		2	Screw, Cap, Hex Head, 3/8” - 16 x 1 3/4”
16	1A-3/8	2	2		2	Washer, Lock, 3/8”
17	29A-3/816	2	2		2	Nut, Hex, 3/8” - 16
18	1N-3/8	2	2		2	Washer, Plain, 3/8”
19	S102-4	1	1	1	1	Regulator

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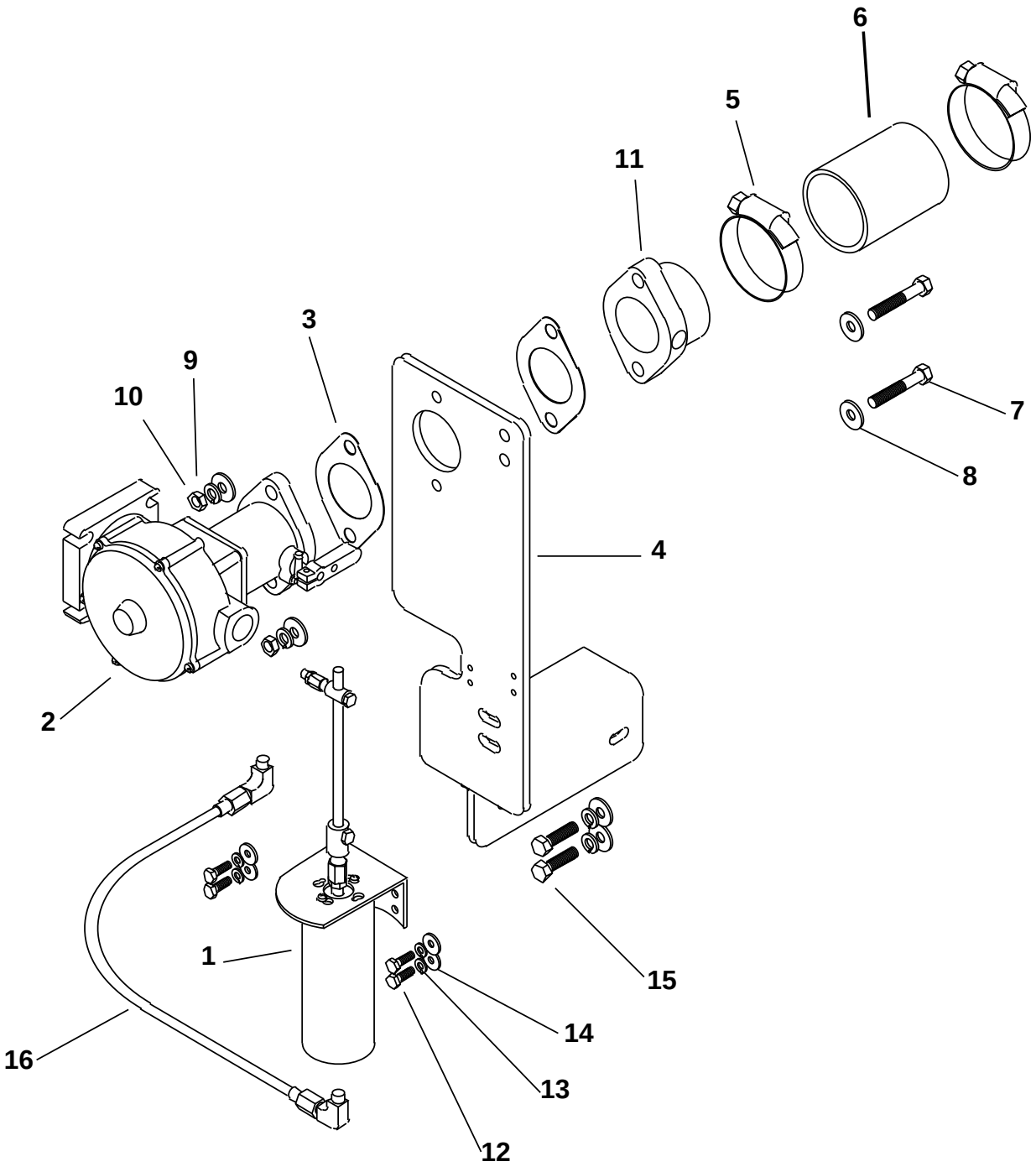
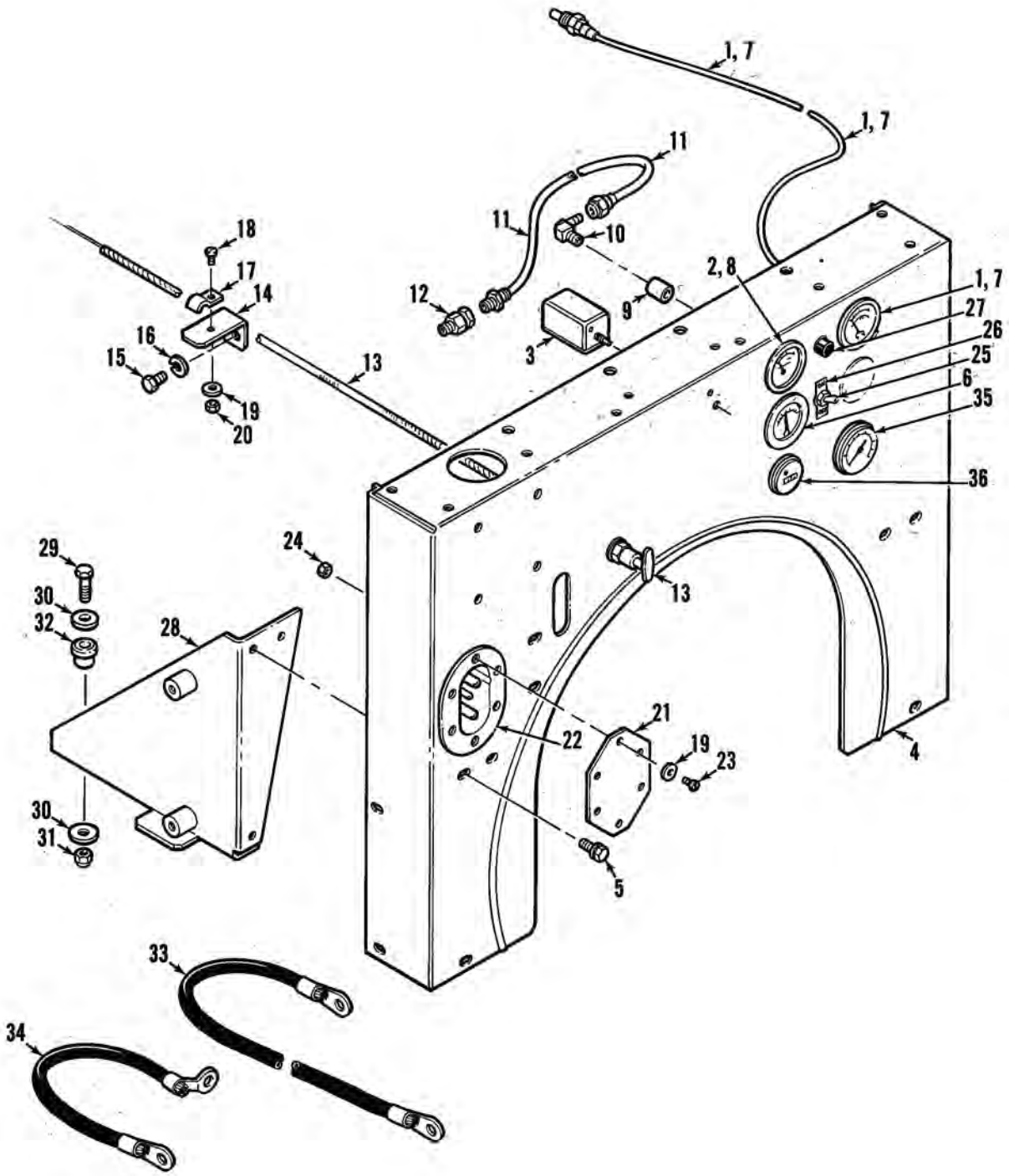


•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Carburetor with Boost Limiter

Group 214

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	500010			1		Powerlimiter - Assembly
2	ASIC-8-B			1		Carburetor, 200, with Flange
3	B1331F			2		Gasket, Carburetor
4	211044			1		Bracket, Boost Limiter
5	41236			2		Clamp, Hose
6	1257-795			1		Hose, 2 3/4” x 2 1/2”
7	7A-3/816X21/4			2		Screw, Cap, Hex Head, 3/8” - 16 x 2 1/4”
8	1N-3/8			6		Washer, Flat, 3/8”
9	1A-3/8			4		Washer, Lock, 3/8”
10	29A-3/816			2		Nut, Hex, 3/8” - 16
11	211043A			1		Adaptor, Carburetor to Hose
12	7A-1/420X3/4			4		Screw, Cap, Hex Head, 1/4” - 20 x 3/4”
13	1A-1/4			4		Washer, Lock, 1/4”
14	1N-1/4			4		Washer, Flat, 1/4”
15	29605			2		Screw, Cap, Hex Head, 3/8” - 16 x 1”
16	OL-A-255			1		Tube, Assembly to Manifold
	211044-1			1		Block, Junction
	211044-2			1		Link, Boost Controller
	211044-3			1		Connecting Tube



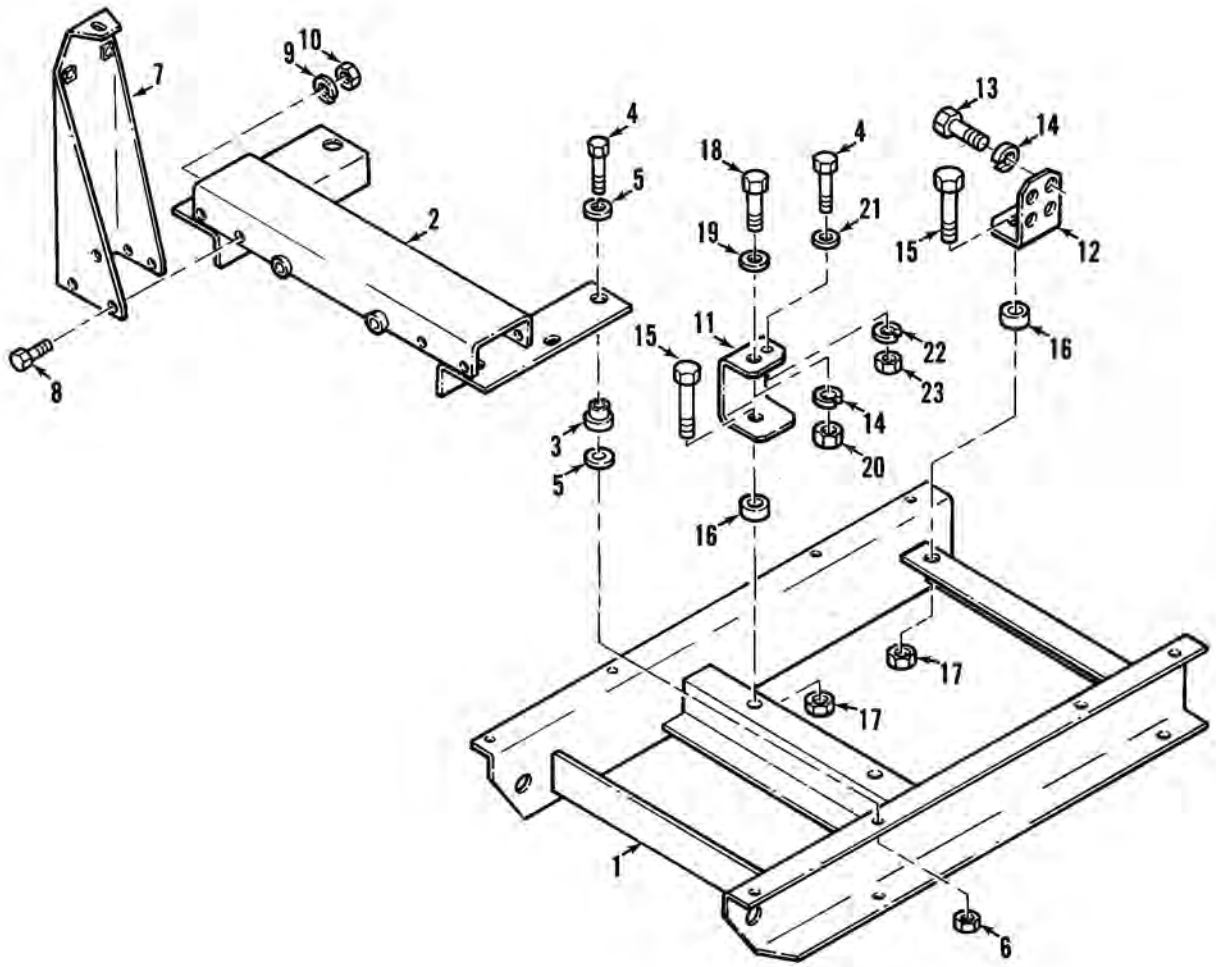
INSTRUMENT PANEL

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Instrument Panel

Groups 213, 215, 220

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
	GROUP 213					
1	120843H	1	1		1	Gauge, Water Temperature and Safety Switch (Optional)
2	120844	1	1		1	Gauge, Oil Pressure and Safety Switch (Optional)
	60356	1	1		1	Oil PSI Switch
3	152934	1	1		1	Switch, Magnetic Ignition
	GROUP 215					
4	A208753C	1	1		1	Panel, Instrument
5	208470	10	10		10	Screw, Cap, Hex Head, 3/8” - 16 x 7/8”
6	60903	1	1		1	Ammeter
7	199472B	1	1		1	Gauge, Water Temperature (Standard)
8	199473	1	1		1	Gauge, Oil Pressure (Standard)
9	78209W	1	1		1	Coupling, Pipe, 1/8”
10	B1686	1	1		1	Elbow, Union
11	50864H	1	1		1	Hose, Flexible
12	B7106C	1	1		1	Adaptor
13	194683S	1				Control, Choke
	194683A		1		1	
14	208852	1	1		1	Support, Choke
15	7A-3/816X1/2	1	1		1	Screw, Cap, Hex Head, 3/8” - 16 x 5/8”
16	1A-3/8	1	1		1	Washer, Lock, 3/8”
17	157568	1	1		1	Clip
18	26456	1	1		1	Screw, Machine, Fillister Head, No. 10-24 x 3/8”
19	1A-#10	3	3		3	Washer, Plain, No 10-24 (With Cover Plate)
	1A-#10	7	7		7	Washer, Plain, No. 10-24 (With Electric Receptacle)
20	21261	1	1		1	Nut, Hex, No. 10-24
21	159195	1	1		1	Plate, Cover (Less Electric Receptacle No. 60247)
22	60247	1	1		1	Receptacle, Electric
23	21128	2	2		2	Screw, Machine, Fillister Head, No. 10-32 x 1/2” (With Cover Plate)
	21129	6	6		6	Screw, Machine, Fillister Head, No. 10-32 x 5/8” (With Electric Receptacle)
24	30A-1032	2	2		2	Nut, Hex, No. 32 (With Cover Plate)
	30A-1032	6	6		6	Nut, Hex, No. 10-32 (With Electric Receptacle)
25	208435	1	1		1	Switch, Toggle
	868-A-255	1	1		1	Key Switch
26	19917	1	1		1	Plate, On-Off
27	60869A	1	1		1	Switch, Push Button
	AE5-43	1	1		1	
28	A209016	1	1		1	Bracket, Support - Right Hand
	A209017	1	1		1	Bracket, Support - Left Hand
29	7A-3/816X13/4	4	4		4	Screw, Cap, Hex Head, 3/8” - 16 x 3/4”
30	B2837	8	8		8	Washer, Plain, 3/8”
31	B9059	4	4		4	Nut, Lock - Elastic Stop, 3/8” - 16
32	208313B	4	4		4	Mount, Center Bonded
33	O120713	1	1		1	Cable, Battery (With Electric Receptacle)
34	O157776	1	1		1	
	GROUP 220					
35	103684	1	1		1	Tachometer, Analog, Reads off the Alternator
	SHD30	1	1		1	Tachometer, Digital, Read off the Mag Pick-Up
36	60662E	1	1		1	Meter, Hour (Optional)



ENGINE SUPPORT

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Engine Support
Group 219

Item No.	Part Number	VR220	VR330	VR330TA	VR330CF	Description
1	2009014D	1				Sub-Base, Engine, Support
	209015B		1		1	
2	209022	1	1		1	Support, Radiator Cross
3	208313A	4	4		4	Mount, Center Bonded
4	7A-3/816X13/4	6	6		6	Screw, Cap, Hex Head, 3/8” - 16 x 1 3/4”
5	B2837	8	8		8	Washer, Plain, 3/8”
6	B9059	4	4		4	Nut, Lock - Elastic Stop, 3/8” - 16
7	A208747	1	1		1	Support, Radiator - Left Hand
	A208748	1	1		1	Support, Radiator, Right Hand
8	7A-8/1618X1	8	8		8	Screw, Cap, Hex Head, 5/16” - 18 x 1”
9	78209W	1	1		1	Washer, Lock, 5/16”
10	29A-5/1618	8	8		8	Nut, Hex, 5/16” - 18
11	209018B	2	2		2	Support, Engine Front
12	209020A	2	2		2	Support, Engine Rear
13	26248	8	8		8	Screw, Cap, Hex Head, 1/2” - 13 x 1 1/8”
14	1A-1/2	10	10		10	Washer, Lock, 1/2”
15	21437	4	4		4	Screw, Cap, Hex Head, 1/2” - 13 x 2 1/4”
16	B715	4	4		4	Spacer
17	119537	4	4		4	Nut, Lock - Elastic Stop, 1/2” - 13
18	7A-1/213X13/4	2	2		2	Screw, Cap, Hex Head, 1/2” - 13 x 1 3/4”
19	1N-1/2	2	2		2	Washer, Plain, 1/2”
20	29A-1/213	2	2		2	Nut, Hex, 1/2” - 13
21	1N-3/8	2	2		2	Washer, Plain, 3/8”
22	1A-3/8	2	2		2	Washer, Lock, 3/8”
23	29A-3/816	2	2		2	Nut, Hex, 3/8” - 16
	VRSKID	1	1	1	1	Shipping Skid

•SUBASSEMBLY
••PART OF SUBASSEMBLY
•••NO LONGER AVAILABLE

Service Repair Kits

Part Number	VR220	VR330	VR330TA	VR330CF	Description
BASIC GASKET SETS					
G-900-1000	1				Gasket Kit
G-900-1001		1	1	1	
SINGLE PISTON RING KIT					
G-907-185	1	1	1	1	Piston Ring Set
CRANKSHAFT AND CRANKSHAFT BEARING KITS					
G-911-209	1				Crankshaft A216011 Kit
G-911-216		1	1	1	Crankshaft A217011 Kit
MAIN BEARING KITS					
G-918-307	1				Standard
G-918-308		1	1	1	
G-918-311	1				.020” Undersize
G-918-312		1	1	1	
HEAD REPAIR KITS					
G-936-2	1				Head Repair Kit
G-936-1		1			
G-936-1S			1		
G-936-1CF				1	
CAMSHAFT BUSHING KITS					
G-927-50	1				Bushings Pre-Reamed
G-927-52		1	1	1	
G-927-48		1	1	1	Bushings Undersize for Align-Boring
SINGLE CYLINDER SLEEVE KITS					
G-932-262	1	1	1		Piston 216104 Kit
G-932-262HC	1	1	1		Piston 216104HC High Compression Kit
G-932-262CF				1	Piston 216104CF Kit
WATER PUMP REPAIR KITS					
G-960-254	1	1	1	1	Water Pump D216160C - Single Groove Pulley
G-960-255	1	1	1	1	Water Pump D216160C-A54 - Double Groove Pulley
SHORT BLOCKS					
G-975-268	1				Compression Ratio 8:1
G-975-277		1	1	1	
VALVE OVERHAUL GASKET KITS					
G-979-231	1				Gasket Set
G-979-236		1			Gasket Set
G-979-262			1		
G-979-236CF				1	
OIL PUMP REPAIR KIT					
G-980-153	1	1	1	1	Oil Pump 216080C Kit

OPERATION & SERVICE

VR220, VR330, VR330TA, VR330CF

ARROW ENGINE COMPANY

FEATURES

Spark Ignited Features:

- Most popular ignition system available
- Demand regulator for gaseous fuel
- Over 40 years history of operating on Natural and well head gas
- Aftercooling featured on VRG330TA

Other Outstanding Features:

- Vertical in-line adjustable fan bracket
- 4 groove crankshaft pulley: 2 groove fan: 1 groove water pump: 4 groove auxiliary
- Flywheel - SAE No. 3 w/ring gear and SAE No. 3 housing
- Lifting eyes - front and rear
- Full pressure lube oil system with full flow oil filter
- Exhaust manifold with top or rear outlets
- 10% regulated speed by mechanical governor - other governor options available
- Heavy-duty, deep skirted crankcase
- Forged steel, dynamically balanced and counterweighted crankshafts with hardened journals
- 5 main bearings on VRG220; and 7 main bearings on VRG330 models
- Replaceable precision main and rod bearings
- Overhead valve cylinder heads with replaceable guides and seats

Options: Consult factory for your requirements.

BRAKE HORSEPOWER DEDUCTIONS FOR ALTITUDE AND TEMPERATURE

Altitude: NA Engines	Deduct 3% for each 1000' (305m) above 1500' (475m) (continuous duty), or above 500' (152m) (intermittent duty). VR330TA - Deduct 3% per 1000' (305m) (continuous duty), 3% for each 1000' (305m) above 1500' (457m) (intermittent duty). EXAMPLE: Elevation = **5,500'** (4,000 (x) .3 = .12) (68 Bhp (x) .12 = 8.16) (68Bhp (-) 8.16 = 59.8) or **60Bhp**
Temperature:	Deduct 1% for every 10ºF (-12ºC) above 100ºF (38ºC) (continuous duty), or above 85ºF (29ºC) intermittent duty). VRG330TA - Deduct 1% per 10ºF (-12ºC) above 100ºF (38ºC) (continuous duty), 1% per 10ºF (-12ºC) above 85ºF (29ºC) (intermittent duty).
Intermittent Rating (I):	The highest load and speed that can be applied under specific conditions of varying lead and/or speed.
Continuous Rating (C):	The load and speed that can be applied without interruption except for normal maintenance.

All ratings corrected to 500' (152m) altitude, 29.38" (746mm) Hg and temperature of 85ºF (29ºC).
Natural gas ratings are based on use of 900 BTU (33.5 J/cm³) HD-5 propane ratings are based on use of 2335 BTU (87 J/cm´) LHV fuel.

POWER RATINGS

I = INTERMITTENT C = CONTINUOUS

MODEL	PEAK INTERMITTENT		BRAKE HORSEPOWER AT SPEEDS INDICATED (S.A.E.)															
Spark Ignited	TORQUE @ RPM FT. LB. N*M		900		1000		1200		1400		1600		1800		2000		2200	
			I	C	I	C	I	C	I	C	I	C	I	C	I	C	I	C
VRG220 Natural Gas	148 @ 1600	201 @ 1600	19	17	24	22	31	28	39	35	45	41	50	45	55	50	59	53
VRG220, HD-5 Propane	191 @ 1400	259 @ 1400	29	26	33	30	43	39	51	46	56	51	61	55	66	60	71	64
VRG330, Natural Gas	220 @ 1600	298 @ 1600	29	26	36	33	47	42	58	52	67	60	75	68	82	74	89	80
VRG330, HD-5 Propane	285 @ 1400	386 @ 1400	43	39	50	45	64	58	76	69	85	76	92	83	99	89	106	96
VRG330CF Natural Gas	233 @ 1600	317 @ 1600			38	35	50	45	61	55	71	64	80	72				
VRG330TA Natural Gas	334 @ 1400	454 @ 1400			50	47	68	63	89	82	97	92	106	100	110		118	

INTRODUCTION

Arrow VR engines are intended for portable and stationary applications such as material handling, portable water pumps, road construction and generator sets. They are four stroke, high speed, overhead valve engines, available in four and six cylinder in-line versions. These engines are capable of running on natural gas.

The information in this manual has been written in an easy to read style and arranged in a time saving manner to provided technical information for Arrow VR220/300 series engines. The common construction features of these engines make it convenient to operate, and to service any engine in the series through the use of this manual.

Differences in procedures due to construction will be pointed out as needed. Overhaul instructions are not included, except where certain special procedures are required. Specifications information, located in the Repair and Replacement chapter (chapter 4), will allow a competent mechanic to determine when parts are no longer usable.

All tabular data and recommendations contained in this manual represent the latest information available at the time of printing, and are subject to change.

Through this manual we have used symbols to stress important information. These symbols and their meanings are as follows:

WARNING This symbol precedes information which, if disregarded, may result in injury or death of the user (or others) of the engine.

CAUTION This symbol precedes information which, if disregarded, may result in damage to the engine.

NOTE This symbol precedes information which is vital to the operation or maintenance of the engine.

SAFTEY PRECAUTIONS

For details on safety rules and regulations in the United States, contact your local Occupational Safety and Health Administration (OSHA).

These safety precautions are published for your information. Arrow Engine Company, does not, by the publication of these precautions, imply or in any way represent that these published precautions are the sum of all dangers present near industrial engines. If you are operating industrial engines, it is your responsibility to ensure that such operation is in full accordance with all applicable safety requirements and codes. All requirements of the United States Federal Occupational Safety and Health Administration Act must be met when Arrow engines are operated in areas that are under the jurisdiction of that United States Department. Engines operated in countries other than the United Stated of America must be installed, operated and serviced in accordance and compliance with any and all safety requirements of that country.

Bodily Protection

Wear OSHA approved bodily, sight, hearing and respiratory system protection. Never wear loose clothing, jewelry or long hair around an engine.

Exhaust Gases

Engine exhaust products are toxic and may cause injury or death if inhaled. All engine installations must have an exhaust discharge pipe so that exhaust gases are delivered into the outside air. A closed building or shelter must be adequately vented to provide a steady supply of fresh air.

Engine Fuels

Natural gas is highly combustible and may ignite or explode. Fuels must be conducted to the engine with proper piping, free from leaks, and designed to resist breakage from vibration. When filling fuel tanks, never smoke or use open flame in the immediate area. Fuel tanks should be grounded to prevent buildup of static electricity. If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition. Then crank the engine to purge the cylinders and exhaust system of accumulated, unburned gas. If you fail to do this, a spark plug could ignite the gas and cause an explosion.

Positive Fuel Shut-Off

Some means of positive fuel shut-off should be provided for emergency use. Pressurized fuels (natural gas, liquefied petroleum gas, etc.) should have another positive shut-off valve, preferably automatic, other than those in the carburetor or gas pressure regulation equipment. It is the final responsibility of the engine owner to ensure that the installation is free from fuel or exhaust leakage, and such installation meets all applicable codes.

Gas Used To Energize Starters

Gas used to energize starters must be discharged away from the engine into a harmless area. Ignition connections and electrical equipment on engines exposed to a potentially explosive atmosphere should be equipped to eliminate spark hazard. It is the responsibility of the engine owner to specify or provide such connections and equipment.

Safety Guards

Engines must be provided with guards to protect persons or structures from rotating or heated parts. It is the responsibility of the engine owner to specify or provide such protection.

Crankcase Anti-Explosion Valves

These valves must be kept in proper working condition to relieve crankcase pressure.

Ignition Systems

Ignition systems can cause electrical shocks. Avoid contacting ignition units and wiring.

A spark plug will fire if the storage capacitor in a breakerless magneto has been charged by hand-turning the magneto. This happens even though the ignition system harness is disconnected at the magneto. When the harness is reconnected, and the ignition switch is in the “on” position, the capacitor will discharge and fire a spark plug. The plug will ignite any gas that has accumulated in that cylinder. The crankshaft and driven equipment may rotate, possibly causing personal injury or damage to equipment. Gas that has accumulated in the exhaust system may also be ignited.

Before reconnecting the ignition harness to a breakerless magneto, discharge the storage capacitor to ground. Do this by clipping one end of a wire lead to the magneto housing. Then touch the other end to the harness connector pins on the magneto. You will hear a snap when a capacitor discharges.

If the ignition switch is in the “off” position, the capacitor is immediately discharged to ground when the ignition harness is reconnected to the magneto.

As a safety measure, ground all the pins. Some breakerless ignition systems have more than one storage capacitor.

WARNING

If a gas engine has been cranked excessively without starting, shut off the gas fuel supply and ignition. Then crank the engine to purge the cylinders and exhaust system of accumulated, unburned gas. If you fail to do this, a spark plug could ignite the gas and cause an explosion.

Cooling System Pressure Caps And Connections

Do not remove the pressure caps while the engine is operating or while coolant is hot. The cooling system is under pressure, and severe burns could result from the hot coolant spewing out when the cap is removed. Wait until the engine and coolants have cooled down before removing the radiator or surge tank caps. Always replace weak hoses, lines, and fittings.

Generator Sets

The voltage produced by generator sets is dangerous. Severe, possibly fatal shock may result from contact. Make sure the generator set is grounded before operation. Be extremely careful when the unit or surrounding area is damp or wet.

When servicing any part of the electrical system or making any connections, make sure main power switch is OFF. Clean or service generator set only when engine is shut down.

In case of an accident from electrical shock, shut down he generator at once. If it cannot be shut down, free the victim from the live conductor. Avoid direct contact with the victim. Use a dry board, dry rope, or any nonconducting implement to free the victim. If the victim is unconscious, apply artificial respiration and get medical help.

Do not operate the generator with the ammeter circuit open. Voltage, dangerous to both equipment and personnel, can be generated in an open secondary circuit of a current transformer.

If the generator set is stopped by operation of safety devices, do not attempt to operate it until the cause has been eliminated.

When the generator set is shut down after operation, disconnected all line switches to all external power load and parallel circuits.

Repair And Service

Always stop the engine before cleaning, servicing, or repairing the engine or driven equipment. Place all controls in OFF position to prevent accidental restarting. If possible, lock all controls in the OFF position. Put a sign on the instrument panel warning that the engine is being serviced. Before restarting, make sure that all tools and other material are removed from the engine and equipment.

Proper service and repair is important to the safe, reliable operation of engines and related equipment. The procedures recommended by Arrow in this manual are effective methods for performing service and repair operations. Some of these procedures require the use of specially designed tools. The special tools should be used when and as recommended. Anyone who uses a service, repair, or installation procedure not recommended by Arrow must first satisfy themselves thoroughly that their safety will not be jeopardized by the service methods they select.

Housekeeping

Good housekeeping results in a clean, safe work area. An orderly work area with clean walkways and neatly arranged tools and equipment is a major factor in accident prevention.

Engine Fan Blades

1. Do not operate the engine with a fan which has been bent, mutilated, modified or in any way damaged.
2. Do not operate the engine if the fan contacts or strikes any engine accessory or the radiator shroud or core.
3. Do not rebalance the fan. Contact the fan supplier if rebalancing is required.
4. Ensure that all bolts attaching the fan are securely installed to a torque specified by the engine or vehicle manufacturer.
5. Install the fan so the word “front” stamped on the fan faces the radiator.
6. Perform all required maintenance on the subassembly to which the fan is attached (water pump, fan drive, etc.) (See operator/ service manual).
7. Do not modify or substitute any parts of the engine without the approval of Arrow Engine Company. Take special care not to make modifications, which will increase the operating speed of the fan.
8. Install the fan only if the engine has been approved for fan installation. Likewise, install a subassembly to which the fan is attached (water pump, fan drive, etc.), only if approved or specified for use on the engine.
9. If the fan or fan drive contains any plastic or rubber component, have the fan and drive inspected by a qualified mechanic after operation at or exposure to excessively high temperatures [above 250° F. (120° C.) air temperature].
10. Replace the fan if indications of excessive corrosion or erosion appear on the fan.
11. For reversible or adjustable pitch fans, make sure the blades are correctly locked in the proper position prior to operation. Also, inspect the fan prior to operation to ensure that ice and dirt have not accumulated on the fan to cause potential unbalance of the fan.
12. Be sure all fans, fan drives and belts are properly shielded.

Turbochargers

Turbochargers are specifically designed for each application. Nozzle rings must not be changed without consulting the engine manufacturer since they limit turbocharger rpm. Excessive rpm may result in turbocharger failure with resultant personal safety hazards. Turbochargers operate at high temperatures. Therefore, all flammable material must be kept away from them. Engines must be shut down at room temperature before working on turbochargers, or burns will result. Keep all foreign material away from turbocharger openings.

Engine Storage Chemicals

Preservative Oil contains a petroleum distillate which is harmful or fatal if swallowed. Avoid contact with skin. Vapor is harmful and causes irritation of eyes, nose, throat and skin. Use only with adequate ventilation. Avoid prolonged or repeated breathing of vapor. Avoid contact with skin, eyes, and clothing. Do not take internally. Keep container closed and away from heat. Always read and observe the “CAUTION” labels on the containers. Do not destroy the labels on the containers.

Generally, heating of preservative compounds is limited to 200° F. (93° C.) or less. These temperatures are easily reached by placing the preservative container in heated water. If this is done, the container must be vented or opened to reduce the danger of explosion. Direct heating presents a dangerous and unnecessary fire hazard.

Fire Protection

Locate fire extinguishers so that they are easily accessible if a fire starts. Carefully maintain records of extinguisher inspection and recharging to ensure the fire extinguishing capabilities when required. Consult your fire extinguisher supplier or insurance engineer for recommendations on the type, size, and quantity of fire extinguishers required. Select and post alternate routes of escape from any engine installation. Design installation to meet all applicable fire codes.

Cleaning Solvents

Use approved cleaning solvents in a well ventilated area. Avoid breathing fumes; some vapors can be fatal. Keep away from open flames or sparks. Do not use gasoline or paint thinners or other highly volatile fluids for cleaning. Always read and observe the “CAUTION” labels on containers. Do not destroy the labels on the containers. Cleaning solvents can cause various types of skin irritations.

Welding Equipment

Welding gas cylinders can explode if damaged. Cylinders must be stored in accordance with manufacturer's specifications and applicable safety requirements.

When using acetylene, check valves should be installed between the regulators and hoses to prevent flashback into the regulators and supply tanks. Flashback could cause the regulators and supply tanks to explode.

Oily and greasy materials must be kept away from oxygen valves. Hoses, etc. Oxygen may combine with such materials and an explosive reaction could result.

Always wear protective eye shields when welding, cutting or watching a welding operation. Protective clothing and face shields must be worn. Do not weld or cut near combustible materials.

Grounding Precautions When Welding

When using an electric welder on an engine, clip the ground lead as close to the welding site as possible. Putting the ground lead too far from the welding site may result in arcing across the main bearings, and fusing them to the crankshaft.

Electric Power Tools

Be certain the electric tool is properly grounded. Wear proper eye protection. Do not work in wet or damp conditions. Be sure the tool is in good condition and safety guards are in position. An electric trouble light must also be grounded. Do not carry electric power tools by the cord. Do not yank the cord when removing from and outlet; instead grasp the plug to remove it from the outlet.

Lead Acid Batteries

Always disconnect the battery ground connection from batteries before performing any work on the engine or equipment. This will prevent sparks or burns from accidentally shorting an electrical connection.

Never expose batteries to open flame or electric spark. Battery action generates a flammable, explosive gas. Don't allow battery fluid to contact skin, eyes, fabrics, or painted surfaces. Battery fluid is a sulfuric acid solution, which could cause serious personal injury or property damage. Wear eye protection when working with batteries.

Precautions When Using Booster Batteries And Cables

Do not attempt to jump start an engine having a frozen battery. The battery may rupture or explode. Before starting, examine all fill vents on the battery. If ice can be seen, or if the electrolyte fluid cannot be seen, do not attempt to start with jumper cables.

Batteries should be treated carefully when using jumper cables. The following procedures assist in reducing sparks and explosion hazards always present in both batteries when connecting charged batteries to discharged batteries:

- Turn off all electrical loads. Remove vent caps and lay a damp cloth over open vent walls of each battery. The charged booster battery or batteries must have the same voltage capacity as the discharged battery or batteries.

- The positive post is identified by a "+", pos. and red color and is larger in diameter than the negative post.

- The negative post is identified by a "-", neg. and gray color.

Negative Grounded Battery Or Batteries

First, connect one jumper cable from the positive post on the charged battery or batteries to the positive post on the discharged battery or batteries. If more than one battery is connected in "series" or "series parallel", connect the jumper cable to the positive post that has the cable leading to the starting motor.

Second, connect the other jumper cable from the negative post on the charged battery or batteries to a good ground on the engine.

When removing jumper cables, always disconnect the ground jumper cable from the engine before disconnecting the other jumper cable.

Positive Grounded Battery Or Batteries

This is the same procedure as for negative grounded battery or batteries, except the negative post will have the cable leading to the starting motor and the positive post will be grounded.

Compressed Air

Compressed air or gases should never be used to clean clothing or the body. Compressed air can pierce the skin and cause severe and very painful injury. Never use your hand to check air, gas, or liquid flow rates. Do not engage in “horseplay” with air, gas, or liquid hoses. Observe all applicable regulations as related to compressed gases.

Sodium Filled Valves

When handling sodium filled valves always wear approved safety goggles, a hat or cap, long sleeves, and gloves. If refacing of sodium filled valves is required, do not exert undue force at the grinding wheel as this could crack the hollow valve stem and allow the sodium to escape.
Do not handle broken sodium filled valves with bare hands. Sodium or sodium residue can cause severe burns. Sodium burns are of the same nature as caustic burns. Wash burns with large volumes of cold water, then neutralize with vinegar. The affected parts should then be treated as a burn and medical attention sought.

If a broken valve should ignite, smother the flames in dry soda ash or dry sand. Water, carbon dioxide in any form, or carbon tetrachloride should never be used on sodium fires since these material react violently with hot sodium. The smoke and fumes are irritating; adequate ventilation should be provided and inhalation or contact with the smoke and fumes avoided.

Broken sodium filled valves may be stored prior to disposal in moisture free clean oil or kerosene. Unserviceable sodium filled valves must be disposed of in accordance with local, state and/or federal regulations as applicable.

Intoxicants And Narcotics

Workers under the influence of intoxicants and/or narcotics are unsafe workers and are a hazard to themselves and other employees.

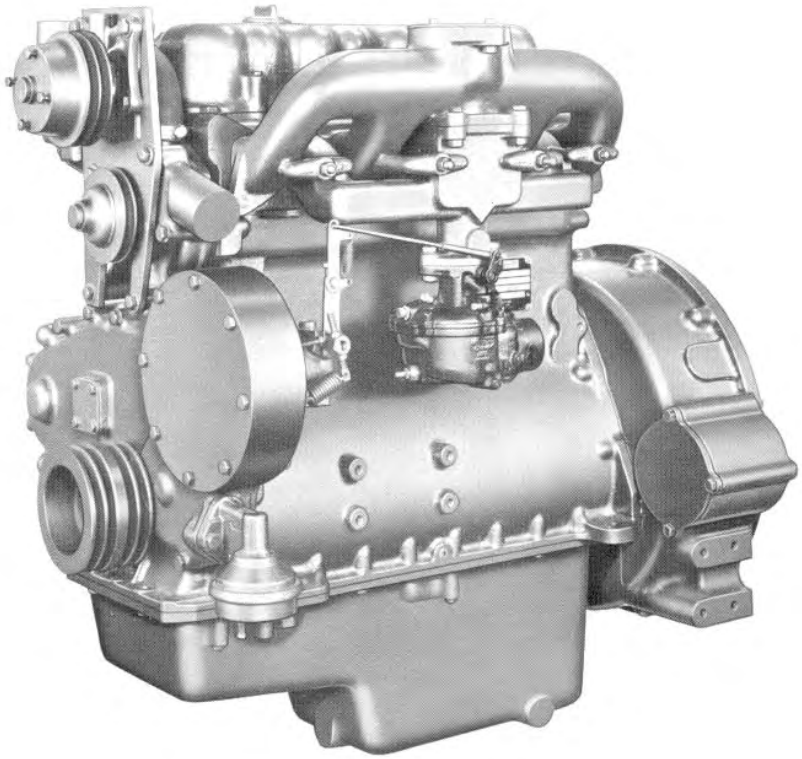
Safety Practices For Handling Acids

Throughout this manual, acid cleaning procedures are recommended for certain castings or pieces of equipment.

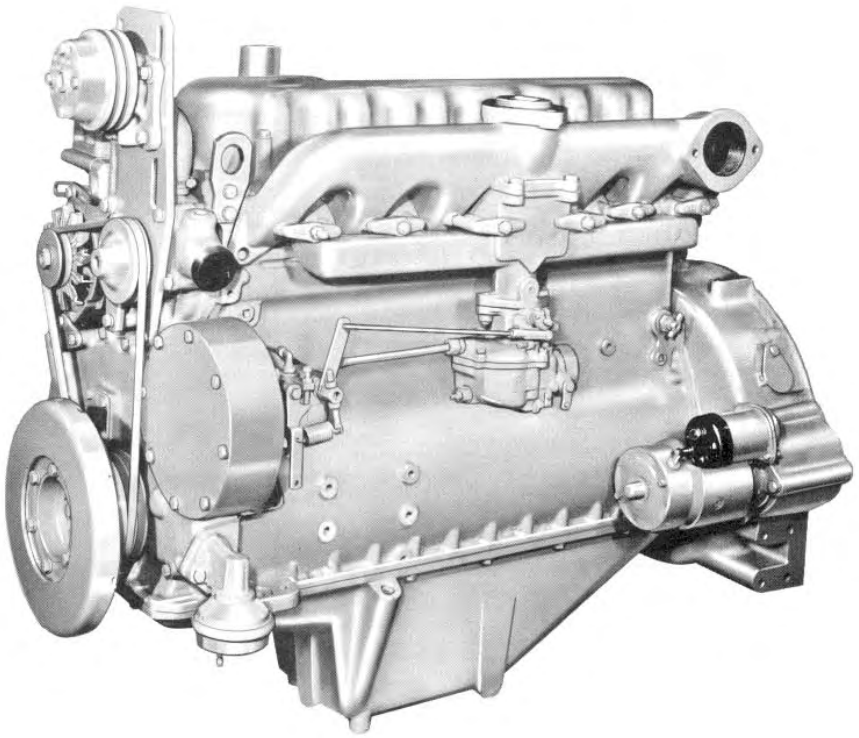
WARNING

Always add the acid to the water - never add water to acid when mixing solution.

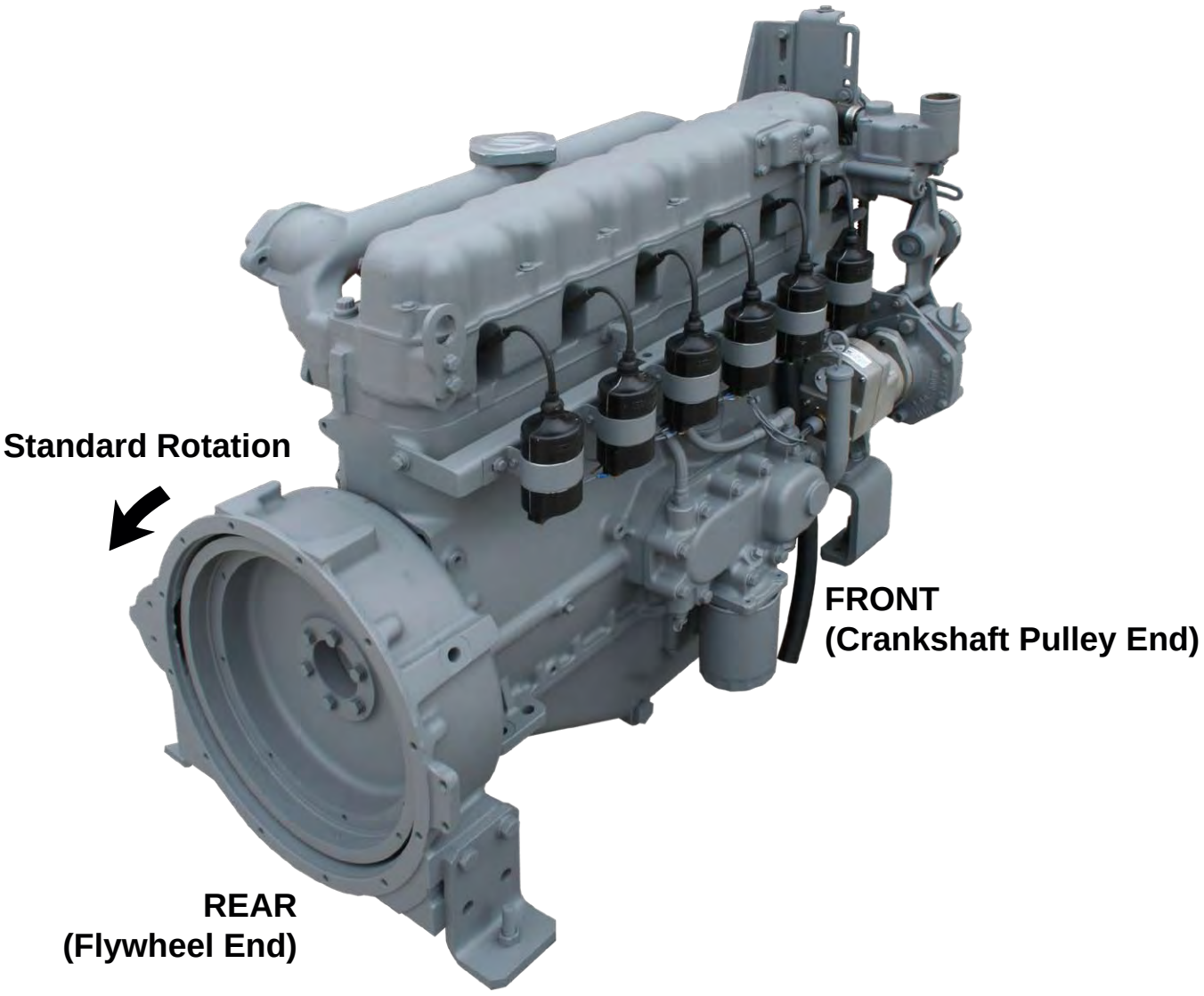
1. Avoid contact with skin, clothing, and eyes.
2. Descaling operations should be performed away from all fire, sparks or other ignition sources.
3. Keep acids off of concrete floors, as it attacks lime in the concrete. If solution does get on concrete surfaces, apply an alkaline solution to neutralize.
4. Acids can react with metals to form various gases. Generally, acid solutions on lime scale and rust result in the formation of harmless carbon dioxide. However, when acids contact aluminum, zinc, cadmium, tin, sulfides, arsenic and cyanides, poisonous and explosive gases may be generated. When descaling is being done in closed equipment, install proper ventilation to carry the gases away. When an open tank or crock is used, gases should be diluted by adequate airflow above the open tank.
5. Always fill closed vessels from bottom up.
6. Be sure that there are no leaks in the vessel being descaled, which will permit solution to leak into opposite side or equipment. Good practice is to fill the opposite side of the equipment being descaled with water to a level higher than the acid solution.
7. Use an acid-proof pump, or an inexpensive, expendable one.
8. When mixing with water, pour acid into the water. Do not pour water in concentrated acid.
9. Do not agitate acid solutions with air.
10. Applications of acid should be followed by thorough rinsing, then neutralizing with an alkaline solution to remove all acidic residue, to prevent further action.
11. Store acid solutions in either an acid-proof wooden or synthetic rubber lined steel container.
12. Check steel equipment to be treated with acid solution for copper or brass fittings or fusible metal plugs. If possible, dissimilar metals should be removed prior to descaling to prevent electrolytic action which might interfere with the inhibiting action of acid solution. Do not use acid to descale equipment constructed of aluminum.

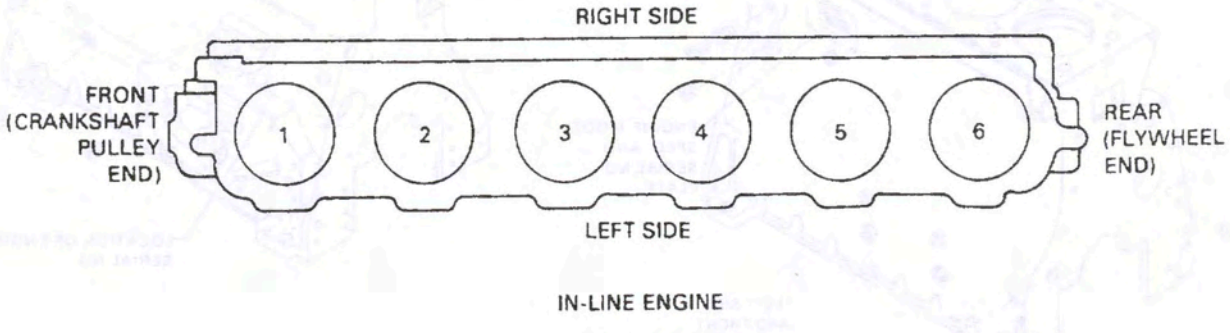


VRG220		
Displacement	Cubic Inches Liters	220 3.6
Bore	Inches Millimeters	3.875 98
Stroke	Inches Millimeters	4.665 118
Normal Oil Pressure at Operating Speed	 PSI@ 2600rpm Kg/cm^2 @ 2600 rpm	 40-50 2.8 - 3.5
Mimimum Oil Pressure at Idling Speed	PSI@ 800rpm Kg/cm^2 @ 800 rpm	12 0.84
Normal Coolant Temperature	 F C	190 - 200 88-93
Spark Plug Gap	Inches Millimeters	0.25 .64
Approximate Dry Weight (Without Balancer)	Pounds Kilogram	800 363
Compression Ratio		8:1 or 10:1

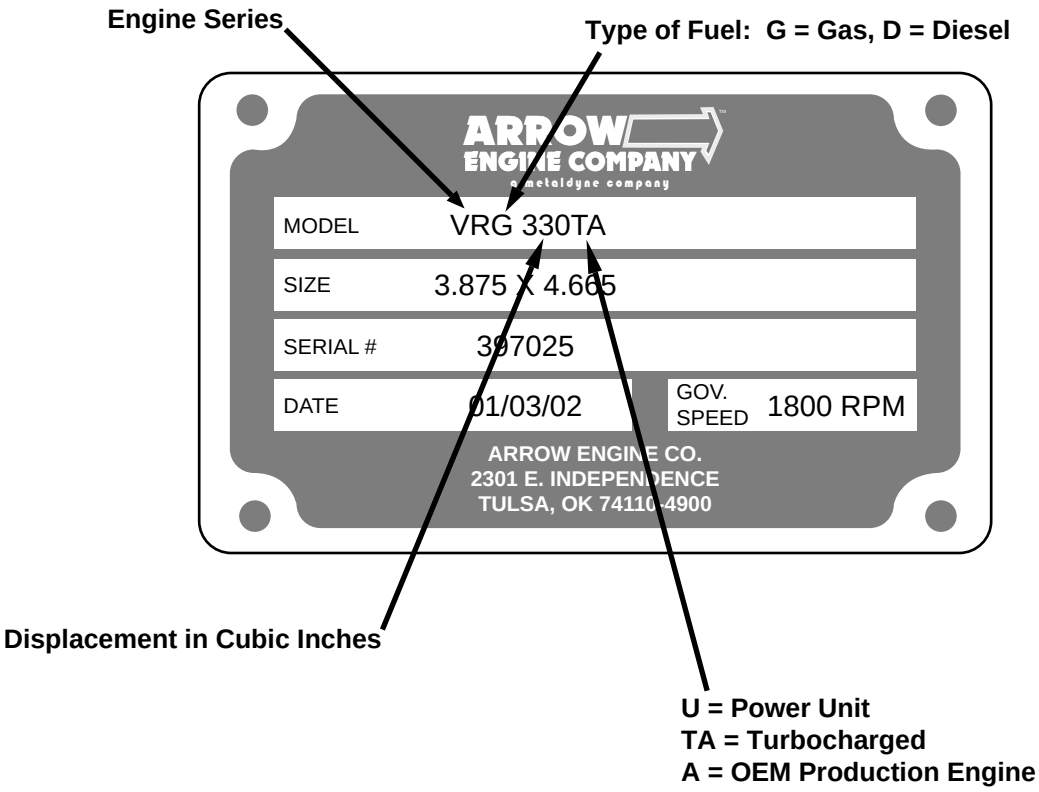


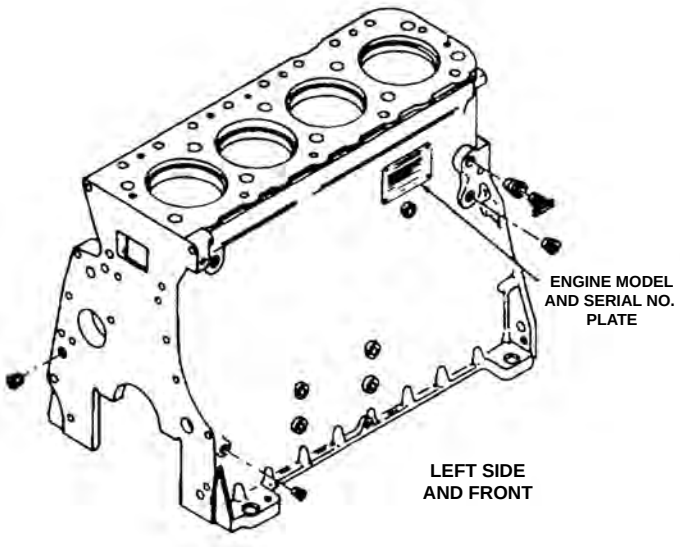
VRG330 / 330TA		VRG330	VRG330TA
Displacement	Cubic Inches	330	330
	Liters	5.4	5.4
Bore	Inches	3.875	3.875
	Millimeters	98	98
Stroke	Inches	4.665	4.665
	Millimeters	118	118
Normal Oil Pressure at Operating Speed			
	PSI@ 2600rpm	40-50	40-50
	Kg/cm^2 @ 2600 rpm	2.8 - 3.5	2.8 - 3.5
Mimimum Oil Pressure at Idling Speed	PSI@ 800rpm	12	12
	Kg/cm^2 @ 800 rpm	0.84	0.84
Normal Coolant Temperature	F	190 - 200	190 - 200
	C	88-93	88-93
Spark Plug Gap	Inches	0.25	0.25
	Millimeters	.64	.64
Approximate Dry Weight	Pounds	1000	1100
	Kilogram	454	500
Compression Ratio		8:1 or 10:1	8:1

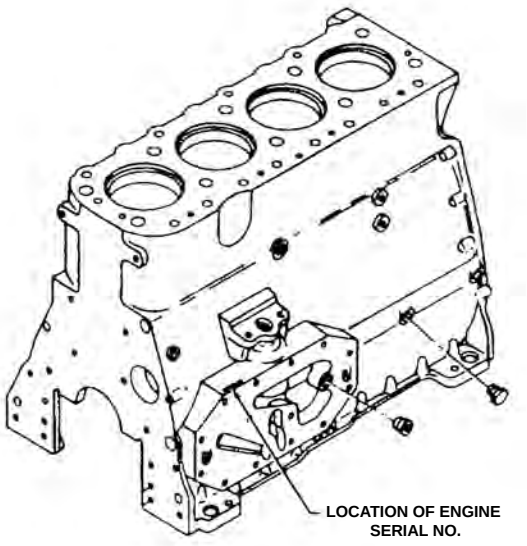




IN-LINE ENGINE

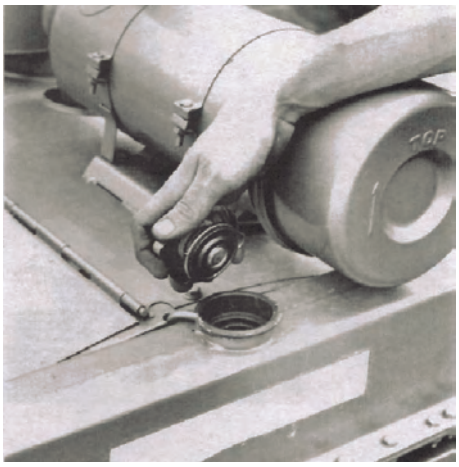






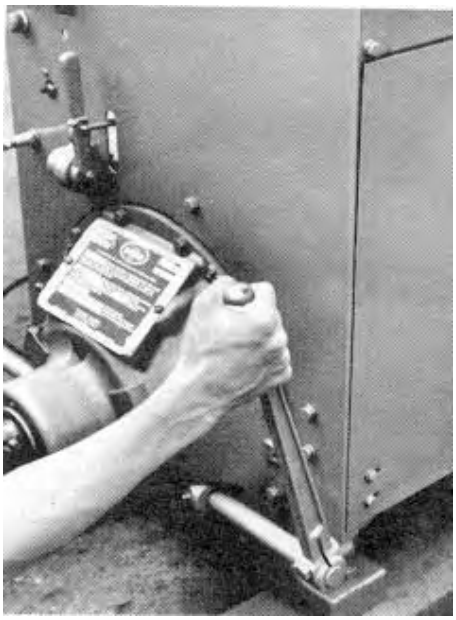
NAME PLATE LOCATION **STAMPED SERIAL NUMBER LOCATION**

BEFORE STARTING



Trace through the external cooling system to make sure all control valves are properly opened, and the drain cocks closed. Check the coolant level.

On post-1996 radiators with baffled top tank, make sure that make up and de-aeration lines are connected between the top tank and the engine. The cooling system will not fill completely if lines are not hooked up correctly. Contact factory for further details.



Be sure the main clutch, circuit breaker, or other power-transmission device is disengaged.

Inspect drive belts (water pump, alternator, fan or other equipment.) Examine for good condition and correct tension. Be sure the cooling fan is free to turn, and the belt tension is correct.

WARNING

Make certain all guards are secure on the engine and driven equipment.

Check the air restriction indicator. Clean the air filter element and dust cap if the indicator shows red.

If the engine has been standing idle for some time, bar it over by hand to be sure it is free to rotate.

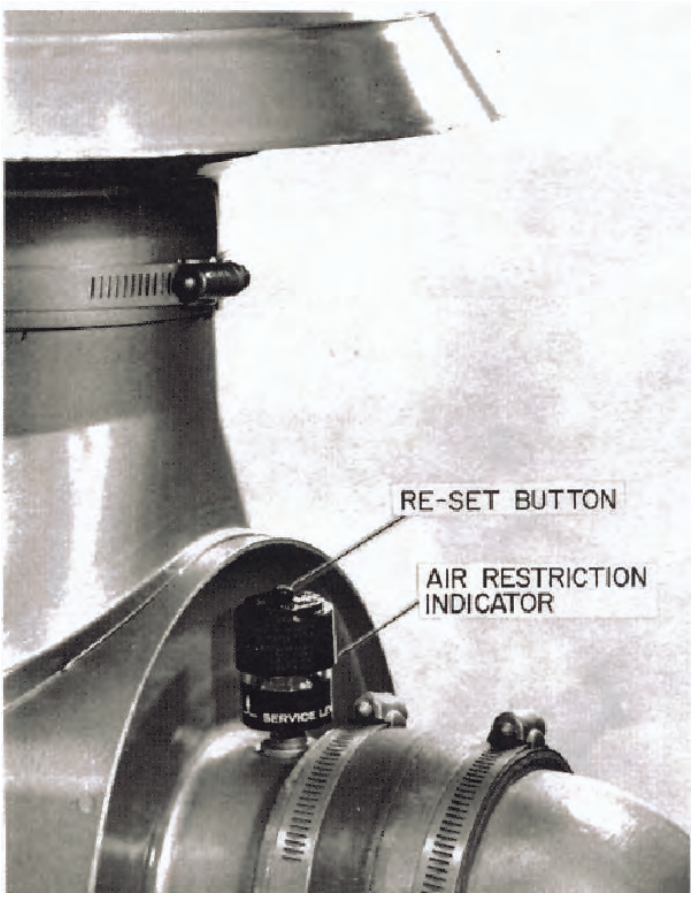
Check the oil level as indicated on the dipstick prior to starting the engine. Stop the engine and recheck the oil level after 5 to 10 minutes of operation at low idle. Add oil as required to bring the level to the “full” mark.

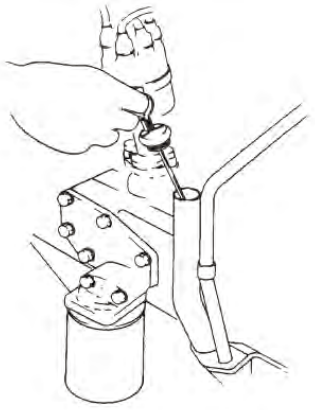
Push in gauge button until lockout engages.

Reset overspeed switch (Synchro-Start) if engine shuts down on overspeed.

Be sure the fuel shut-off valve is opened prior to attempting to start the engine.

Familiarize yourself with all engine controls before attempting to run the engine.





STARTING ENGINE

Place the throttle control lever in the “low speed” position. Actuate the starter control to crank the engine. After the engine starts, check for adequate oil pressure indications and place the throttle control lever in the medium idle speed position with no load for engine warm-up. Check that the Murphy Swichgage safety control (when applicable) has released so that the engine cannot operate with low or no oil pressure. The Swichgage must be released by oil pressure before the low oil safety control is effective.

CAUTION

If adequate oil pressure is not indicated within 15-20 seconds, shut the engine down at once and determine the cause. Never operate an engine without adequate oil pressure readings in the hope that a faulty gauge or cold oil is responsible. (The problem could be something else, and serious engine damage would result.)

Idle turbocharged engines for several minutes after starting to prevent “oil lag” failure to turbocharger bearings. This is particularly important during cold weather or when the equipment has not been in use for extended periods.

Warm up engine until oil pressure stabilizes and coolant temperature reaches at least 100° - 120°F. (38° - 49°C.)

Check general engine security such as air intake and exhaust connections, belt, guard, bolts, etc.

Engine speed for applying load will vary depending upon engine application. Generally, load should be applied gradually with engine speed set high enough to carry the load.

There are a number of important things to check while the engine is running.

Learn and record the normal operating readings for the engine. Normal oil pressures for the VR220/330 series engines are 40-50 psi (2.8-3.5 kg/cm2) at 2600rpm. The normal coolant temperature is 190-200 °F. (88-93°C).

Check the air intake restriction indicator.

Listen to the engine. Certain problems, such as occasional misfiring, may first be noticeable at first.

Check for oil or coolant leaks.

Avoid prolonged idling, in excess of 20 to 30 minutes at a time, without bringing the engine up to normal operating temperatures near full-load. Excessive idling periods tend to cause cylinder and turbocharger problems by creating excessive coke and ash deposits.

STOPPING ENGINE

Remove load by disengaging the clutch control lever, opening the main circuit breaker, etc.

Place the throttle control lever in medium idle speed position, and allow the engine to idle for a few minutes to reduce and normalize engine temperatures.

CAUTION

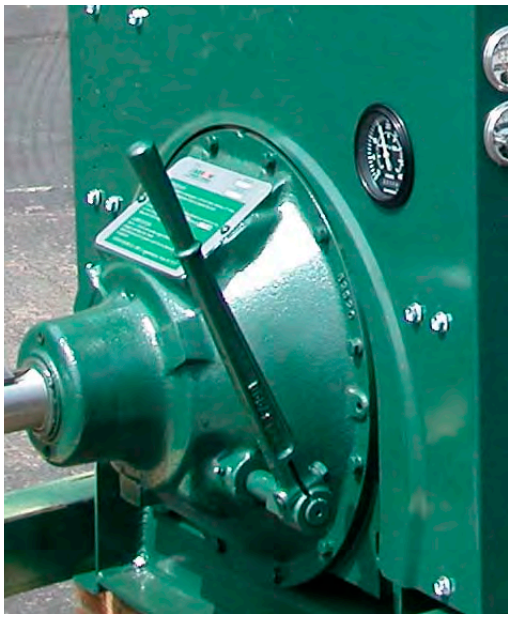
It is advisable, if the engine has overheated due to either excessive load or through some malfunction of the cooling system, to operate the engine at idle speed for a few minutes to bring temperature back to normal. This is especially important for a turbocharged engine. If temperature does not begin to recover to normal within one minute, shut the unit down hot.

Stop the engine when it has cooled sufficiently. Depending upon the engine installation, it can be stopped in a number of ways.

Gas engines should normally be stopped by shutting off the fuel supply.

Unless otherwise protected, the exhaust pipe should be capped upon shutting down the engine to prevent condensation, rain, or snow from getting into the engine. A pail or bucket inverted over the exhaust pipe will be sufficient.

Test the coolant solution for adequate antifreeze to protect the engine from freezing during shutdown periods. The immediate and anticipated air temperature will govern the amount of antifreeze needed.



QUICK TROUBLE INFORMATION FOR OPERATORS

CHECK CONTROLS	Follow starting steps. Reset safety controls. Remote or automatic operation engines have special procedures.
CHECK FUEL SYSTEM	Be sure fuel is getting to engine; check valves for open position; check possibility of water, rust, pipe scale.
CHECK COOLING SYSTEM	Check coolant level. Make sure the system is not air locked. Radiator must not be blocked. Check shutter and fan operation. Raw water valves must be open to the heat exchanger.
CHECK AIR INTAKE AND EXHAUST SYSTEMS FOR BLOCKS	Check air filter and air restriction indicator. Air intake or exhaust outlet must be uncapped.
CHECK MECHANICAL ITEMS	Check throttle and governor control linkage for freedom from sticking and interference. Examine accessory drive belts for condition and tension. If cranking speed seems low, check battery condition.
CHECK IGNITION ON GAS ENGINE	Check for water on ignition parts and wires, signs of corrosion at wire terminals, broken wires, and spark plugs that are poorly gapped or worn out.

IF THESE CHECKS DO NOT SOLVE THE PROBLEM, REFER TO THE TROUBLESHOOTING SECTION

START-UP

Cold Weather Starting

An engine jacket coolant heater, lubricating oil heater, and / or other approved starting aid should be utilized as required for cold weather starting.

Engine Warm-Up

Proper engine warm-up is important for long engine life. A warm-up period allows for an even thermal expansion of engine components. Also, the lubricant warms up and attains normal viscosity during warm-up. Oil pressure is also built up, assuring proper oil distribution and lubrication of vital engine parts.

(Standby units that require immediately full load pick-up can be equipped to maintain a constant oil pressure and engine temperature. Consult your Arrow distributor for further information.)

Break-In Procedure

New or overhauled engines should receive a break-in run.

NOTE: *Standby generator engines should follow this procedure using a load bank.*

EXERCISE OF STANDBY UNITS

It is recommended that a generator set or other standby unit be exercised once each week. A record should be maintained of performance, incidental servicing, and output of both the engine and driven equipment.

Always operate the engine long enough to stabilize oil and water temperatures at the normal operating level expected under load. Do not operate under no load conditions for other than very brief periods. Loads of at least one-third up to the normal rated capacity are recommended. Ordinarily, an exercise run of 1-1½ hours will be needed to stabilize temperatures. If the engine cannot be loaded, it should not be exercised for more than 10 minutes each exercise period.

It is recognized that some types of driven equipment cannot be operated without fairly extensive procedures to “put them in line”. Examples are hospital generators in some types of switching configurations: air-conditioning compressors which can only be loaded by changing over to chilled water from heating water circulation; and pumps which are not set up for waste discharge or recirculation.

In such cases, weekly exercise periods may have to be reduced, where possible, to operational periods long enough only to prove the engine's ability to crank and start; or, checkout of starting circuitry and safety equipment with the starter disabled. In this event, special attention must be taken to prevent internal corrosion, sticking and gumming of fuel controls, and deterioration of starting batteries. In all cases, arrangements should be made to run the engine and driven equipment under load at least every 90 days.

Light Load Operation Service Schedule

We recommend the following maintenance schedule for engines that are consistently run at 25% or less of the continuous duty rating.

1. Maintain engine jacket coolant temperature between 180° and 190° F. (82° - 88° C.).
2. Air cleaner restriction indicator should be checked daily. Clean or replace element as required.
3. At 50 operating hour intervals, run the engine at 50% load or better to clean carbon off the engine components.
4. The inspection and overhaul schedule of cylinder heads should be updated to allow for a 25% reduction in hours between servicings.
5. Our experience indicated that lightly loaded gas engines will have more stable operation when equipped with single electrode spark plugs. However, for heavily loaded gas engines, we recommend the use of multi-electrode spark plugs as they provide better performance and longer service life.
6. Change lube oil every 500 hrs.

When applicable, we recommend running fewer engines per site to increase the load on each engine.

NOTE: *When operating above 25% of the continuous duty rating, follow the normal maintenance schedule.*

Engine Performance Record

Engine operating information, recorded during regular inspection, is necessary to apply proper Preventive Maintenance schedules. Accurate records help control costs by avoiding unnecessary servicing, ensuring needed servicing, and providing "trend" information on the general engine condition. We recommend keeping a record of the following information, selecting items applying to your engine.

Hour Meter Reading	
Tachometer (Rpm)	
Fuel Meter Reading	
Engine Oil Pressure	
Engine Oil Temperature	
Coolant Temperature	
Gas Pressure @ Carb Intake	
Manifold Vacuum	
Crankcase Pressure +/-	
Unusual Noise(S) Vibration	
Oil Leaks	
Coolant Leaks	
Alternator Output	

Operational Inspection

Examine fuel, water, and lubricant lines for signs of leaks, damage, or corrosion.

Inspect the coolant level and condition. Rust, foaming, or oil in the coolant indicates need for cooling system servicing.

Air cleaners and breathers should be checked daily for cleanliness and tightness.

Examine engine foundation for condition of grout, tightness of hold down bolts, and general alignment of driven equipment.

Fuel

NATURAL GAS - VR Series gas engines are designed to burn natural gas. Natural gas is normally considered as having an anti-knock (octane) rating equivalent to 120

SERVICE

Lubrication Recommendations

The following precautions should be observed when lubricating the engine.

1. Keep all lubricants in closed containers and store them in a clean, dry place away from heat. Always protect the lubricants from dust, dirt and moisture. Keep lubrication equipment clean and ready for use at all times.

2. Before adding oil, wipe surrounding areas clean to prevent dirt or other foreign matter from entering the lubrication system. Use a cloth moistened with solvent to remove any old or hardened lubricants. After lubricating, remove any excess oil and wipe any spilled lubricant from parts not requiring lubrication.

The performance of a lubricant, like that of any manufactured product, is the responsibility of the refiner and producer. A tabulation of lubricant producers and suppliers, together with performance grades for which the producers have indicated their products are qualified, is available in the "EMA Lubricating Oils Data Book", complied by the Engine Manufactures Association, One Illinois Center, 111 East Wacker Drive, Chicago, Illinois 60601. Arrow Specialty Company has made it a practice not to recommend oil by brand name.

Arrow Specialty Company's warranty is limited to the repair or replacement of parts that fail due to defective material or workmanship during the warranty period. The VR Engine warranty does not include responsibility for satisfactory performance of the lubricating oil, this being the responsibility of the oil supplier.

Service Conditions

Oil performance will reflect engine load, temperature, fuel quality, atmospheric dirt, moisture and maintenance. If oil performance problems arise or are anticipated, the oil supplier should be consulted.

Extended oil change intervals should be utilized with caution on any engine using highly dispersant oils, The dispersants function by absorption of particles of contaminants; however, when dispersant saturation is reached, these oils tend to "dump out" all of the suspended contaminants in a relatively short period of time. Laboratory analysis will not predict the "dump out" point precisely; consequently, closer operator attention to engine conditions is required when establishing an extended oil change interval.

Hydrogen Sulfide

Engines operating with gaseous fuel containing over 0.1% hydrogen sulfide should use oil compounded to a TBN (total base number) of 8 or higher, so that the oil can adequately counteract the acids formed in the combustion of such fuels.

When fuel is burned in an engine combustion chamber, any sulfur it contains is converted to sulfur oxides, which will combine with water vapor to form acids. These acids can cause serious corrosive damage to engine components. The engine oil should be compounded to neutralize these acids and inhibit corrosion. This is done by building alkalinity into the oil via the additive formulation. The commonly used measure of relative alkalinity is termed Total Base Number (TBN). The higher this number, the greater the reserve alkalinity or acid neutralizing capacity of an oil.

The following table gives guidelines for required TBN of new oil, and deterioration limit of used oil for a range of liquid fuel sulfur content. The recommended oil drain intervals for each engine model should be followed, unless the TBN drops below the minimum valve shown before that time. If this happens the oil should be changed immediately.

SULFUR, WT% IN LIQUID FUEL	Up to 0.5	0.5 to 1.0*	1.0 to 1.5*
TBN - NEW OIL	8	14	20
MINIMUM TBN (ASTM D664) IN USED OIL	4	4	4
* Consult Arrow Engine Company for use of high sulfur fuels.			

Lube oil suppliers will supply information about the TBN levels of their products. An oil analysis program will keep the user informed of the TBN level of his oil in service so that adequate corrosion protection is maintained.

Since low operating temperatures promote condensation of acid-bearing fumes in the crankcase, engine coolant temperatures should also be maintained at 185° F. (85° C.) minimum when using such fuels.

ENGINE LUBRICATION TABLE

API, SAE, ASTM Letter Designation	**CC, SD, SE**
Military Designation	**MIL-L-46152, MIL-L-2104B**

OIL CHANGE INTERVALS

Continuous Duty - At continuous duty rating, clean environment with oil sump temperature 230ºF (110ºC) or below	Engines operated in **Excess of Continuous Duty** rating	**Light Load**	**Standby Service**
500 hrs.	200 hrs.	500 hrs.	300 hrs and/or annually
NOTE: *Lube oil and fuel filter elements should be changed when lube oil is changed.*			

DEFINITIONS	
Continuous Duty	24 hrs. a day - 7 days a week
Continuous Duty Rating	BHP produced - See Power Rating Chart
Light Load Operation	25% or less of continuous Duty Rating - See Power Rating Chart
Standby Service	Normally exercised 2 hrs. per month and operated during emergency conditions. If emergency conditions exist in excess of 2 continuous hours, load requirements should be adjusted to Continuous Duty Rating.

Convert Btu to Gallons for Propane Consumption

1. Propane has 101,050 Btu/Gal
2. VR/A Series engines consume 8,000 Btu/bhp-Hr of propane
3. 8000 x 68 Bhp = 544,000 Btu per hour
4. 544,000 x 24 hours = 13,056,000 Btu per day
5. 13,056,000/101,050 = 129 Gallons of propane Per day

EXAMPLE: If 1,000 Gallons of propane is used in 8 days = 1000/8 = 125 Gallons per day

Oil Designation

Oil is designated in several ways, including the API, which is usually stamped on the container, the military, and the engine manufacturer's designations. The preceding is satisfactory for the VR engines. The designations listed are not necessarily equivalent.

Sulfated Ash Content in Motor Oil

.04 - .06	Low
.06 -.09	Medium
> 1.00	High

CAUTION

The type of oil, engine environment and installation, internal engine condition and/or the condition of the carburetion equipment may require more frequent oil changes. We suggest monitoring the lubricating oil with a good oil analysis program. However, extended oil change intervals may cause varnish deposits, oil oxidation or sludge, which an oil analysis cannot detect.

Low Temperature Operation

At low ambient temperatures, an oil must be used which will provide proper lubrication when the engine is hot and working. Lube oil and jacket water heaters are recommended for ambients below 50°F. (10°C.) to warm oil and water for fast starting and loading of engines. Arrow Specialty Company will supply information on these devices upon request.

Multi-viscosity oils should only be used in cold starting applications. However, the oil may deteriorate in continuous service, allowing the oil to revert to its original low viscosity base. In this state, the oil may not supply sufficient film strength and/or oil pressure. Therefore, an oil analysis program should be utilized to determine the oil change intervals.

Synthetic oils are not recommended by Arrow Engine Company due to insufficient experience with the product.

Oil Consumption

Oil consumption should range from 0.0005 to 0.004 pounds per horsepower hour as determined by the following formula:

LBS/Hp-HR= 1.82 x quarts of oil used/
Operating Hp x total hours of operation

Oil Viscosity Selection

The operating temperature of the oil in the sump is the best guide for selecting the proper SAE grade of oil. When the oil temperature is unknown on VR Series engines, add 120°F. (67°C.) to the ambient temperature to obtain the estimated sump oil temperature.
For example: at an air temperature of 70°F. (21°C.), estimated oil pan operating temperature would be 190°F. (88°C.). Use SAE 30 as indicated in the following table.

NOTE: *This is only an estimate, since the type of installation determines the amount of air circulation of cooling around the oil pan. Actual oil pan operating temperatures should be measured whenever possible.*

The correct lubricating oil viscosity (often referred to as "weight") should be determined with the engine operating under its normal loaded speed and temperature, using SAE 30 oil.

6. Start and load the engine as described under "STARTING".

7. After oil and coolant temperatures stabilize, note the temperature of the oil in the oil pan. Use an accurate temperature gauge. Compare this temperature with the accompanying chart. The correct oil viscosity will be found in the right hand column.

CLASS "A" ENGINES	
SUMP TEMPERATURE	**SAE No.**
210 - 250ºF (99 - 121ºC)	40
160 - 210ºF (71 - 99ºC)	30
130 - 160ºF (55 - 71ºC)	20

Engines operating with low oil temperatures [below 160°F. (71°C.)] can be expected to show excessive sludging and water. Engines operating with high oil temperatures [above 230°F. (110°C.)] may experience lacquering and ring sticking due to oil oxidation. If, for any reason, oil temperatures cannot be corrected to the normal operating range, more frequent oil changes may help in extending engine life.

Oil Changes

The crankcase level should be checked prior to each day's engine operation. The oil condition as revealed on the oil level dipstick should be carefully observed.

Replace oil if it is plainly diluted, broken down, thickened by sludge, or otherwise deteriorated. Remember that some modern oils cannot be judged on the basis of color alone because the additives are intended to hold carbon particles in suspension.

The standard filters supplied will not remove these particles. The dark appearance of the oil is not necessarily an indication that the oil should be changed. Whenever oil is changed, the filters must be serviced.

Oil Change Procedure

1. Remove the crankcase oil drain plug, drain oil and securely replace the plug.

2. Fill the element with oil (approximately one quart). Replace the filter element.

3. Fill the crankcase with oil.

4. Operate the engine for a few minutes in order to circulate the oil through the system.

CAUTION

If adequate oil pressure is not indicated within 25 to 30 seconds, shut the engine down at once and correct the cause. Never operate without an adequate oil pressure indication in the hope that a fully gauge or cold oil is responsible.

5. Stop the engine and check oil level. If necessary, add oil to bring the level to the "full" mark on the oil level dipstick.

OIL CAPACITY		
VR330 with filter only	8.5 qts.	8 liters
VR330 with filter and cooler	9.0 qts.	8.5 liters
VR220 with filter only	7.0 qts.	6.6 liters
VR220 with filter and cooler	7.5 qts.	7.1 liters

Not all oils in every type of engine will give maximum service; therefore be careful to examine the oil after the first draining to determine whether it is standing up in service. Trial periods of ten hours are suggested; and at the end of such periods, make careful inspection of the oil level dipstick for sludging, frothing and emulsification. Such conditions call for more frequent oil changes or a different oil. In winter operation, low oil temperatures [below 160°F. (71°C.)] are particularly likely to cause sludge formation. Temperature control devices (curtains, shutters, and so on) should be used if needed in order to hold the oil temperature around 180°F. (82°C.).

Break-In

New or overhauled engines should receive a break-in run.

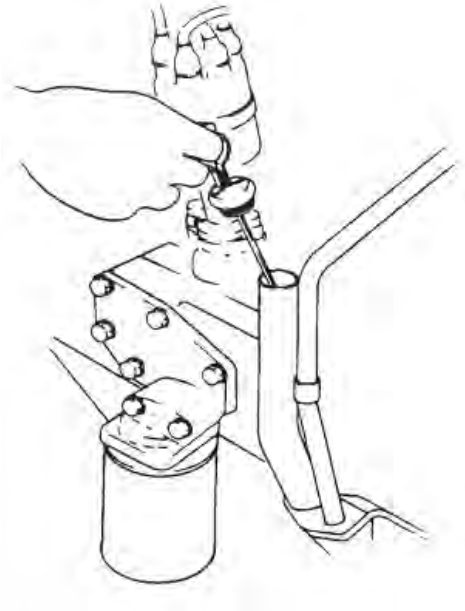
This operation can be performed with the lube oil as specified below. After warm-up of approximately 30 minutes, proceed with a load and unload cycle. Repeated loading (minimum of half load, maximum full load), with equal idle periods in 5-minute intervals for a period of two hours, results in rapid break-in and quick seating of piston rings. Never idle the engine for more than 15 minutes during the break-in or for the first 100 hours of operation.

NOTE: *Standby generator engines should follow break-in procedures using a load bank*.

Service Schedule And Procedures

Oil and Coolant Level

Check levels daily and fill as required. Change the oil and filter as recommended under “Oil Change Intervals”.



Air Filters

Check the restriction indicator daily and clean the filter if the indicator shows red.

Fan and Water Pump Belts

Check belts weekly for proper tension and material condition. Make sure guards are secure.

Valve Adjustment

Adjust valve clearance every 500 hours.

Battery

Check electrolyte level weekly and fill as required. Inspect terminals for corrosion periodically. A specific gravity of between 1.250 - 1.285 with all cells within 0.010 and 0.015 of each indicates a well charged battery.

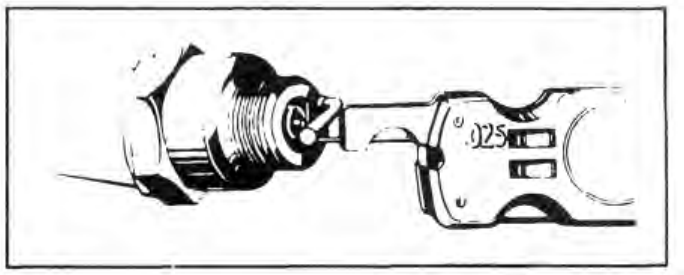
Natural Gas Carburetor And Regulator

Inspect the diaphragm annually and replace if cracked or deteriorated.

Spark Plugs

Inspect spark plugs every 250 hours and replace every 500 hours. Spark plug gap: .025” (.64 mm) gasoline and gas.

Spark Plug Size: 14 mm.



Crankcase Breather

Clean the breather every 1000 hours.

Power Take-Off

Lubricate the power take-off at intervals according to the instructions of the manufacturer.

Turbocharger (VRD220TA and VRD330TA only)

Clean and inspect every 6 months.

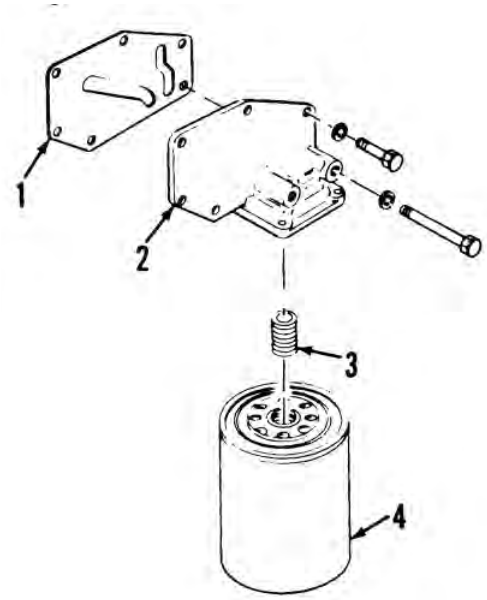
Oil Pump Inlet

The inlet of the oil pump is a slotted pickup tube designed to protect the pump and engine from the introduction of foreign material. If an indications of low or fluctuating oil pressure appear, the pickup tube should be thoroughly washed in a suitable solvent.

Oil Filters

VR220/330 Series engines are equipped with full flow oil filters. These are spin-on, disposable type filters. When changing filters, carefully follow the manufacturer's directions.

Full flow filters are an integral part of the lubrication system. Never run the engine with the filter blocked off. All oil going to the engine must pass through the filter. If the filter becomes clogged, the oil will bypass the filter. The engine will then be lubricated with dirty oil, which may reduce engine life. To avoid this possibility, we recommend changing the oil filter at every engine oil change.



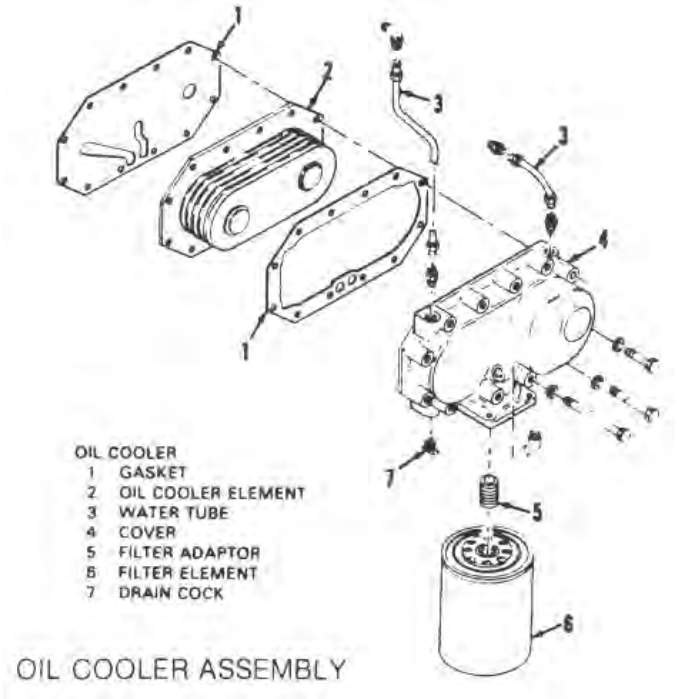
OIL FILTER ASSEMBLY

OIL FILTER

1. GASKET
2. FILTER BASE
3. FILTER ADAPTOR
4. FILTER ELEMENT

Oil Cooler (When So Equipped)

Oil cooler maintenance consists of largely of periodic cleaning and inspection for clogging or corrosion. Improper or fluctuating oil pressure, or an undesirable increase in oil temperature may indicate the need for servicing the cooler more frequently. In general, the cooler should be removed from the engine, disassembled, and cleaned annually, or as required. Long service or expediency may make it more practical to replace the inner cooling core with a new unit. All rust and lime deposits should be removed from the water passage area of the cooler. The sludge deposits within the cooler core may be cleaned out by several solvents and methods; but in all cases, it is recommended that cleaning take place as quickly as possible after removing the cooler from the engine. Ordinarily, a cleaning solvent or a commercial sludge and carbon remover will be effective if pumped vigorously through the cooler plates. Observe fire and safety precautions.



OIL COOLER ASSEMBLY

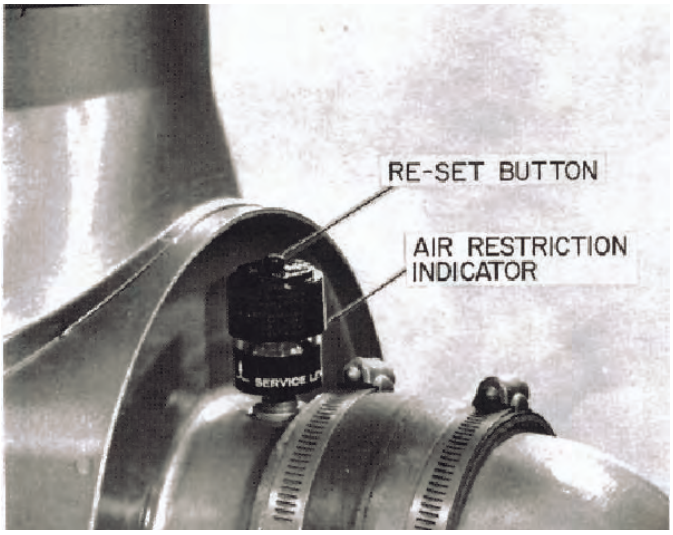
Air Cleaners

Follow the directions attached to the cleaner if any are present. Dry-type air cleaners are used on VR220/330 engines.

An air restriction indicator is mounted in the piping for the air cleaner. This indicator shows when air cleaner element service is necessary.

WARNING

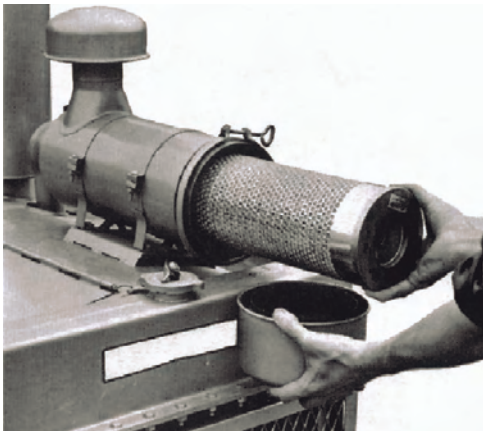
The air cleaner condition indicator communicates directly with the intake manifold and is subject to occasional high pressure if gas engines backfire. A restrictor is normally installed in the air passage to dampen momentary high pressure which might damage the indicator and project broken pieces potentially harming nearby people. A check should be made to be certain this restrictor is actually in place.



As dirt trapped by the air cleaner gradually restricts the flow of air, the condition indicator signal, which is preset for a maximum restriction, rises within the gauge. When the maximum restriction is reached, the signal locks into full view indicating the need for servicing the air cleaner element.

CAUTION

Unless the signal is locked in view, indicating a clogged air cleaner element, the restriction indicator will return to a normal setting upon engine shutdown. Normally the air cleaner element is serviced long before the indicator shows a need, but the operator should check the indicator every day while the engine is running. After the air cleaner element has been serviced, the reset button on the restriction indictor should be depressed to reset it.



Two styles of dry-type air cleaners are available to VR Series engines. Open units are equipped with an upright hat style air cleaner. The second type available is the circular style air cleaner supplied with VR Series closed units. This style cleaner has a precleaner built into each assembly. Dirt trapped by this precleaner is collected in a dust cup on the end of the cleaner element, be careful not to spill any dirt on the engine. (This cleaner is also available as an option for the VR Series open units.)

REMOVING DUST CUP

There are two ways to clean dry-type air cleaner elements.

CAUTION

Do not rap, beat or drop the element.

1. Compressed air cleaning. Direct clean, dry air [max. 100 psi (7.0 kg/cm2)] inside the element, moving the nozzle up and down while rotating the element.

2. Water wash cleaning. Soak the element 10 minutes in lukewarm water and nonfoaming detergent solution. Rinse with water [max. 40 psi (2.8 kg/cm2)] from the inside of the element until the rinse water is clean. Air dry; **do not** use compressed air to dry.

Inspect after cleaning by placing a light inside the element. Replace the element if it is ruptured, has pinholes or damaged gaskets. Always replace the element after three cleanings or 6 months, whichever occurs first.

Cooling System Maintenance

When adding antifreeze compounds on a percentage basis remember to include the coolant volume of the radiator and other external parts of the cooling system. The following table should be used as a guide:

COOLING SYSTEM CAPACITY			
Ethylene Glycol (Prestone)	**Radiator Glycerine (G.P.A.)**	**Freezing Points**	
		°F	**°C**
16%	37%	20	-7
25%	55%	10	-12
33%	70%	0	-18
39%	81%	-10	-23
44%	92%	-20	-29
48%	100%	-30	-34

To prevent rust when using water alone, add one ounce (29 cc) of soluble oil for every gallon (3.7 liters) of coolant in the cooling system.

Cooling Capacities, Engine Only

COOLING CAPACITIES - ENGINES ONLY		
VR330 without oil cooler	8.25 qts.	7.8 liters
VR330 with oil cooler	9.25 qts.	8.8 liters
VR220 without oil cooler	7.0 qts.	6.6 liters
VR220 with oil cooler	8.0 qts.	7.6 liters

Never fill the cooling system with only water if the engine is to be exposed to subfreezing temperatures. This applies even when warm water is used, because the water in the radiator and jacket passages cools rapidly and is likely to freeze during the next shutdown, Mix the proper proportion of antifreeze and water before filling the engine.

To drain the cooling system, drain the external components and remove the drain plug from the left rear side of the engine, and from the oil cooler (when so equipped).

Under normal conditions, the heat-sensitive thermostat in the water outlet will maintain temperatures within the desired limits of 190° - 200°F. (88° - 93°C.)

CAUTION

Remember that if the engine is to be operated with the thermostat removed - and this is not recommended except in emergency - some provision must be made to block off the bypass passage or water will continue to recirculate without passing through the radiator or other external cooling system. Shutters or other means will be required to maintain the temperature at the desired level.

Thermostat Removal And Testing

Ordinarily, thermostats will seldom need replacement in the field. They should be checked annually, however, and are quickly accessible by removing the thermostat housing at the forward end of the cylinder head. To accomplish this, simply remove the water outlet connection hose, and the cap screws securing the housing, Thermostats damaged by corrosion or other causes are not repairable and must be replaced.

Thermostats should be tested in hot water for proper opening. A bucket or other container should be filled with sufficient water to cover the thermostat. Suspend a good quality thermometer in the water so that the sensitive bulb portion does not rest directly on the bucket bottom or side. A stove or torch is used to bring the water to a heat range of 170°F. (77°C.), while the thermostat is submerged in the water.

Stir the water for even heating. As the temperature passes the 175°F. (79°C.) range, the thermostat should start to open and should be completely open when the temperature has risen to about 195°F. (91°C.). Lifting the thermostat into the colder temperature of the surrounding air should cause a pronounced closing action and the unit should close entirely within a short time.

A large thermostat is used to ensure adequate reserve circulation for heavy operation and to pass large volumes of cooling water. Be careful to seat the thermostat squarely and concentrically to avoid interference with the thermostatic action. Also, be certain the thermostat seal is in place.

Cleaning The Cooling System

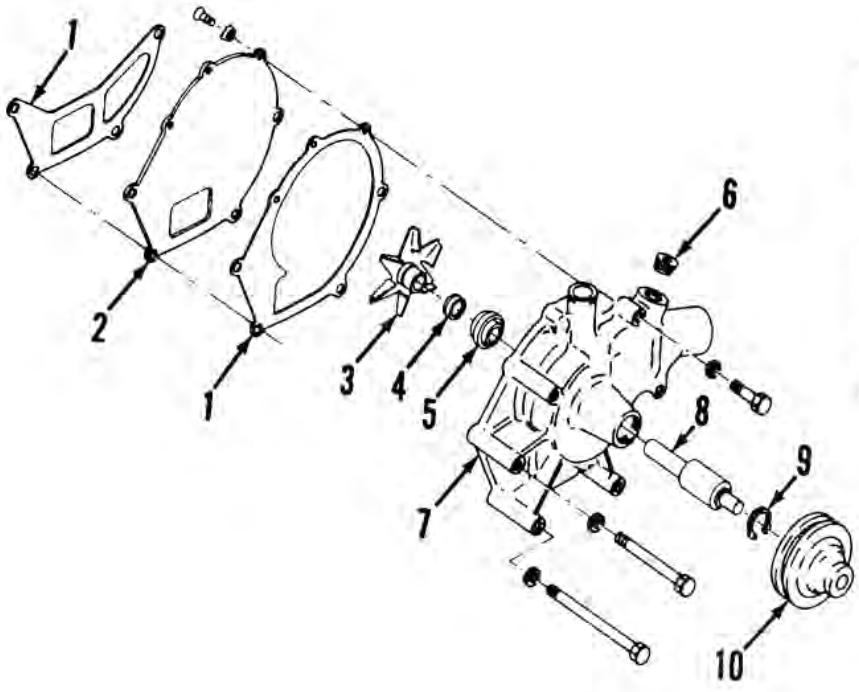
When clean, soft water is used as a coolant, and when the proper inhibitors or antifreeze solutions are used, radiator and cooling passage accumulations will not be excessive. About once a year, however, the engine will benefit if the cooling system is cleaned of sludge and sediment.

A number of excellent commercial cooling system cleaners are available. Arrow Specialty Company suggests, however, that an operator considering the use of such a cleaner first investigate its possible reaction with the copper and bronze parts in the engine. If such a cleaner is used, follow the manufacturer's recommendations carefully.

The belt driven water pump requires no special packaging or attention during its service life. The durable water pump has an internal seal, used in combination with a permanently lubricated integral ball bearing and pump shaft.

When servicing this water pump, the entire shaft, bearing, and seal must be disassembled from the pump body. Since an arbor press is required to remove the seal, field repairs are not recommended unless such equipment is readily available.

The sealing member of the pump consists of a smooth carbon washer riding against a polished surface.



WATER PUMP

1. GASKET
2. COVER PLATE
3. IMPELLER
4. SEAL SEAT
5. SEAL
6. PLUG, ZINC PLATED
7. PUMP BODY
8. WATER PUMP SHAFT AND BEARING
9. RETAINING RING
10. PULLEY

Using A Timing Light

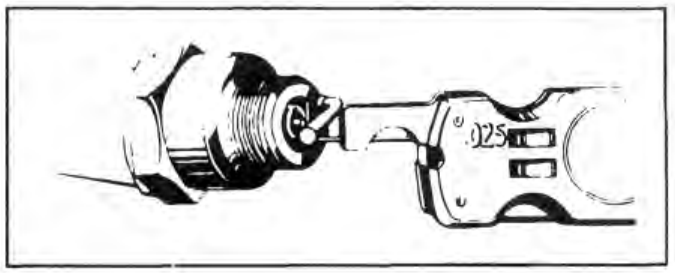
1. Connect the timing light power leads to the battery observing proper polarity (if applicable).
2. Connect the timing light signal lead into the number one spark plug lead, using the supplied adaptor.
3. Remove white plastic cap from timing adjustment screw.
4. Start engine and aim the timing light at the timing hole pointer in the flywheel housing. Some engines have a notch in the crankshaft pulley and a timing pointer out the front gear cover. Be sure to aim directly toward the center. On some models a button on the timing light will have to be pushed to cause light to flash; on others the light will flash automatically. The correct firing degree mark on the timing tape should now appear under the reference pin. If not:
5. Using a slotted screw driver, turn the timing adjustment screw to desired setting.
6. Reinstall white cap on timing screw.

Spark Plug Adjustments

Misfiring or ragged operation may be due to faulty spark plugs caused by carbon accumulations and burning of the electrodes. They should be cleaned, inspected, and the gaps checked approximately every 250 hours of operation, or more often if the engine idles for prolonged periods. After 500 hours, it is advisable to replace the entire set when any spark plug is defective.

Deposits on the electrodes and insulator can be removed by commercial abrasive cleaners. Scraping the insulator is not recommended, since the resulting scratches increase the tendency of forming carbon deposits.

After the spark plug has been cleaned, and the center electrode filed, adjust the gap with a round wire gauging tool to .025" (.64 mm) by bending the outer electrode. Since the spark plugs will have a tendency to burn the electrodes and widen the gap, it is important that the gap be checked whenever the plugs are removed from the engine. Engine misfiring at low speeds is very often due to a wide spark plug gap.



Checking Spark Plug Gap

Examine plugs for cracked porcelain, leakage, burned electrodes, deposits on the center insulator, and incorrect gap. Check washer, thread, and seating surface conditions. Remember, a plug may appear satisfactory and not fire properly.

NOTE: *When replacing spark plugs, use new gaskets. Proper seating of the gasket is necessary for sealing the combustion chamber and transfer ring heat from the plug. Use spark plug tap to clean threads. Clean threads allow for proper heat transfer.*

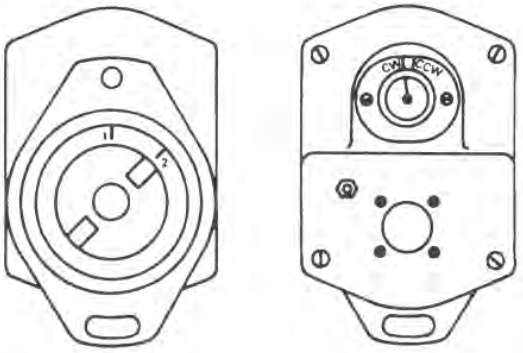
Magneto Servicing

The magneto is a solid state, capacitor discharge type. There are no breaker points to adjust or replace. Repair and overhaul operations require specialized training and equipment and should be made only at authorized service agencies.

Timing The Magneto

The magneto timing procedure follows the steps given for timing the distributor very closely. The flywheel must be rotated until the proper timing mark aligns with the timing hole pointer in the flywheel housing and the number one piston is coming up on the compression stroke. This is the point at which firing occurs when the engine is running.

Locate the timing marks on magneto housing for clockwise rotation. Rotate drive gear until the red mark on the shaft lines up with clockwise mark on housing. The figure below shows the timing mark indication and drive coupling alignment.



Mount unit to engine keeping the above two red lines together as close as possible, loosen magneto mounting fasteners and adjust magneto as required to realign timing marks.

Final timing is done with the flange mounting screws snug. Connect a battery powered timing light to the spark plug lead of the number one cylinder and check the timing with the engine running. If the timing is not correct, tap the magneto by hand enough to rotate it on the mounting flange. With careful tapping, one direction or the other as required, exact timing is readily determined. The flange mounting screws must then be tightened.

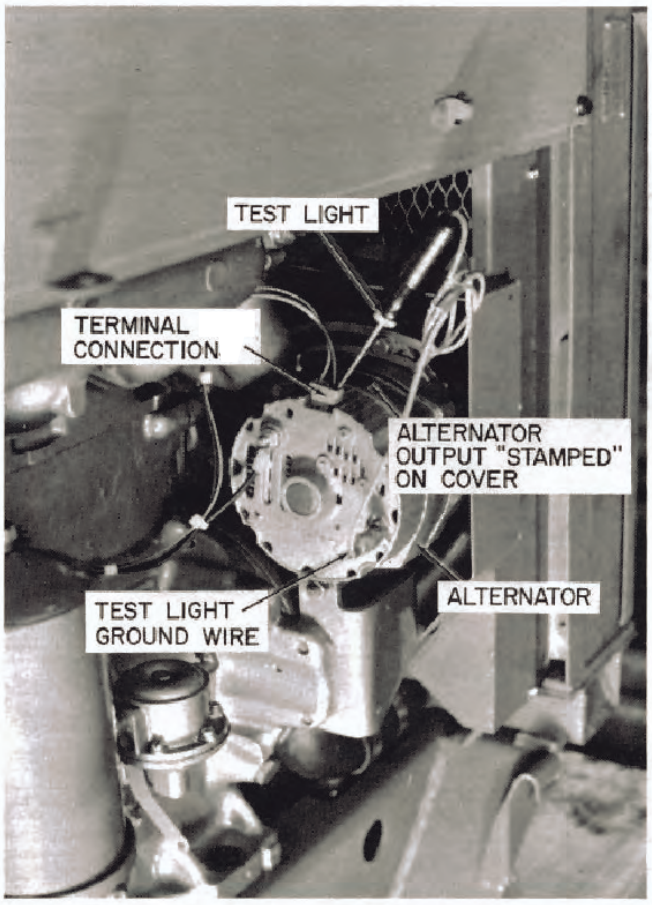
Alternator Servicing

Alternator servicing within this manual is limited to testing the unit on the engine and replacing it if defective.

Continuity Testing

1. With the engine off, check the drive belt for proper tension.
2. For external field excitation only

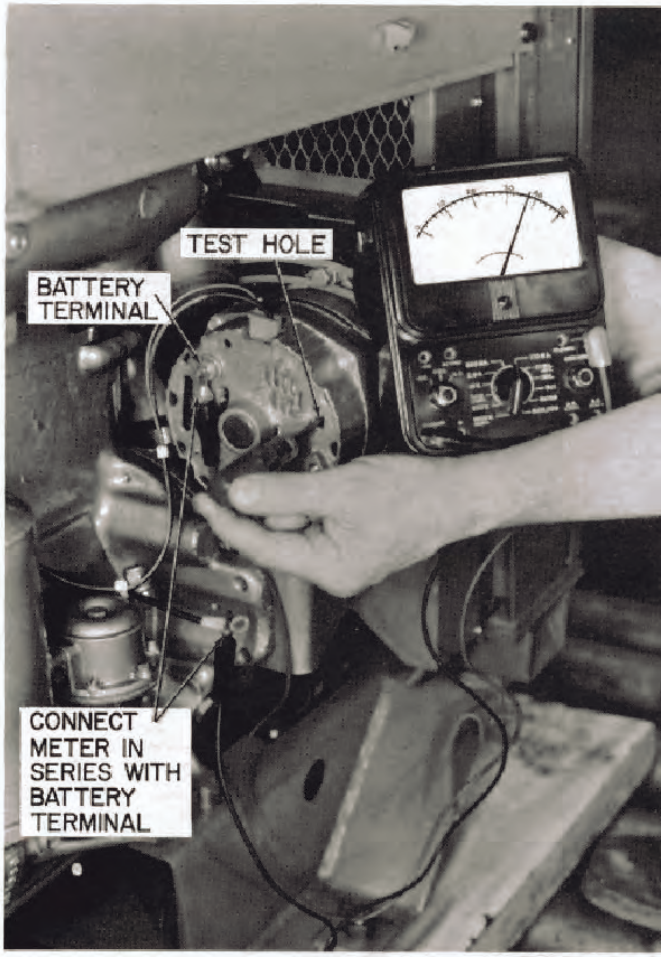
If the tach is inoperable, check for A/C on back of tach. Our alternators are self exciting. On engines equipped with the CD-1 ignition, if the B+ cable is removed from the battery and the engine dies the alternator is bad.



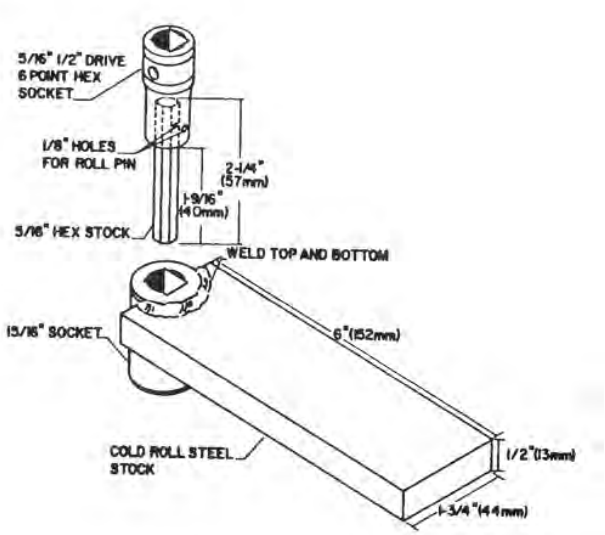
TESTING ALTERNATOR WIRING

Output Testing

Remove the battery wire from the alternator battery terminal and connect an ammeter in series as shown in the illustration. Run the engine at 1000 - 1200 rpm. Should read 13.7 VDC for older Delco alternators.



TESTING ALTERNATOR OUTPUT



ALTERNATOR PULLEY NUT TIGHTENING TOOL

REMOVING THE ALTERNATOR PULLEY

Alternator Pulley Removal And Installation Tool (Delco Remy Alternators Only)

When replacing the alternator, remove the alternator pulley and retain it for use with the replacement alternator. A special tool has been designed to perform this step. The materials and dimensions for making this tool are included in the illustration.

When installing or removing the alternator pulley nut, place the pulley nut holder in a vise and position the alternator into the nut holder as illustrated. Use the allen wrench attachment to loosen or tighten the shaft-to-pulley nut. The pulley nut should be torqued to 60 ft. lbs. (81.35 N-m).

CARBURETOR ADJUSTMENTS

The normal installation for natural gas uses a field regulator to reduce pounds pressure to the final value of 5" (127 mm) water column (3 oz.) maximum. Excessive pressure will increase gas fuel consumption and cause hard starting.

WARNING

For reasons of safety, all gas installations in closed areas or buildings should have a positive shut-off valve to prevent gas leakage when the engine is at rest.

With the Arrow carburetor, VR Series engines use a 1" line pressure regulator with a 3/8" orifice. The regulator utilizes spring 1B6538 (red) with 5-10 psi (.35 to .70 kg/cm2) inlet line pressure and 5" (127 mm) water column outlet pressure to the carburetor for 1000 BTU LHV gas.

The main mixture valve will be full open and there will be no idle screw in the side of the carburetor main body. All settings will be fixed for emissions (natural gas only LPG may be different.)

Low Idle Adjustment

1. Reduce the throttle speed setting to bring the carburetor butterfly valve lever against low idle stop.
2. Adjust the carburetor idle stop screw to obtain the desired engine rpm.
3. Adjust the carburetor idle fuel adjustment screw to obtain the highest engine rpm.
4. Re-adjust the idle stop screw to obtain the desired engine rpm.

Lp Gas Carburetor Adjustments

The adjustment sequence for Arrow carburetors when operated on liquid or vaporized LPG is very similar to the adjustment sequence for natural gas, with the following exceptions:

CAUTION

We recommend only HD-5 propane for LP-gas fueled engine operation. All data in this manual is based on the use of HD-5 propane.

1. LP gas inlet pressure to the carburetor must be 1" to 1 - ½" (25 to 38 mm) (negative) water column as set by the IMPCO "JB" vaporizer regulator (blue spring)
2. If vaporized LPG is used, the pressure reducing valves (with regulator spring removed and valve mounted upside down) provide 1" to 1 - ½" (25 to 38 mm) water column negative pressure to the carburetor fuel inlet. Line pressure regulators utilized with vaporized LPG are adjusted the same as for natural gas to supply 5" (127 mm) water column gas pressure to the pressure reducing valve.

Digester Gas Carburetor Adjustments

For low BTU fuels (500 to 800 BTU) such as digester gas, a special DG carburetor must be used. Digester gas should be regulated to the carburetor at approximately 6" (152 mm) water column pressure. For digester gases of different heat values, slightly higher or lower pressures are required and adjustment is normally made in the field.

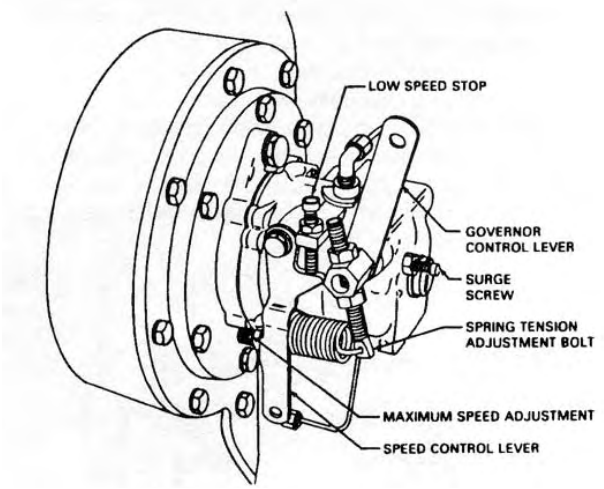
Ignition timing for digester gas should be set the same as for natural gas.

Adjustment procedures for a digester gas system differ from natural gas adjustments only the 6" (152 mm) water column gas pressure required at the carburetor fuel inlet. Carburetor adjustments are the same as for natural gas systems.

GOVERNOR ADJUSTMENTS

Should the governor and linkage have to be dismantled to permit access to the engine for other service work, there are some basic requirements to be followed. Upon disassembly the parts of the governor and linkage must be carefully marked so they will be reassembled in exactly the same position. The length of the linkage must be carefully noted so that when the engine is stopped and the throttle lever is in full speed position, the throttle valve stands just a trifle toward the closed position. Variation from the proper speed can be corrected by changing the tension of the regulating spring. Increasing the tension increases the maximum speed, and decreasing the tension decreases the maximum speed.

As an aid to quick stabilization at minimum and maximum speeds, a small surge screw is incorporated.



Valve Clearances

Accurate valve clearance settings prolong engine life and aid performance. In addition to impairing performance, excessive clearances are detrimental to camshafts and valve lifters.

On the other hand, when the clearances are too tight, timing is disturbed and the possibility of burned valves increases.

Valve clearances specified in the Basic Engine Data section of this manual and on the engine timing plate are for normal room temperatures, not for hot engines.

To adjust the valves:

1. Remove the rocker arm cover and bar the engine over until number 6 cylinder (number 4 on four-cylinder engines) is at the valve overlap point. (This is when the exhaust valve is nearly closed, and the intake valve is just beginning to open.) You can now adjust the valves on cylinder number 1, since it is no the compression stroke with both valves closed (valve lifters on base circle).

2. Use a feeler gauge to check the clearance between the valve stem and the rocker arm. To adjust the clearance, loosen the lock nut on the adjusting screw. Turn the adjusting screw until you feel a slight drag on the feeler gauge.

3. Tighten the lock nut. Recheck the clearance to be sure you did not turn the adjusting screw when you tightened the lock nut.

The remaining cylinders in the firing order are adjusted in the same way. The following charts show what cylinder valves to adjust at each valve overlap point.

Adjust the valves on this cylinder…	…when this cylinder's valves are at the overlap point
VR330 SERIES ENGINES	
1	6
5	2
3	4
6	1
2	5
4	3
VR220 SERIES ENGINES	
1	4
3	2
4	1
2	3

Compression Testing

To check the compression of gas engines, a standard automotive type compression tester with a threaded adapter can be used.

Before checking compression, be sure the engine has been warmed up to operating temperature. The throttle must be held in the open position and the ignition switch in the shut off position. Note the number of compression stokes needed to obtain the highest pressure reading. Repeat compression testing for each cylinder using the same number of compression strokes as used for the first cylinder tested.

Normal compression pressures at cranking speed are listed in the "Repair and Replacement" unit under "Basic Engine Data". Uneven compression or pressures lower than normal call for further checking. Valve regrinding, piston ring replacement, or other overhaul procedures may be required to correct the problem.

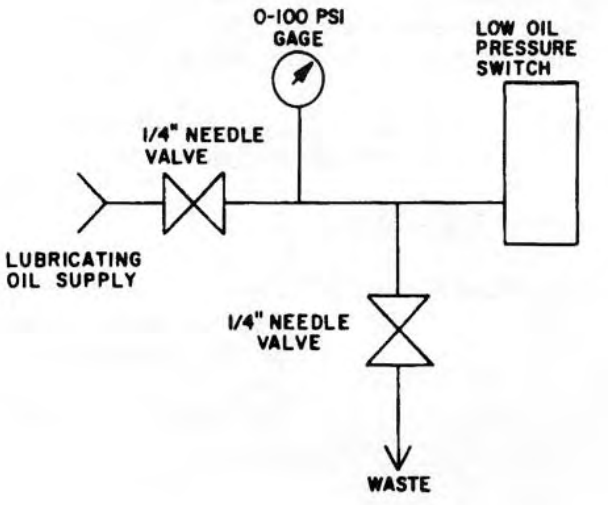
GAUGE READINGS	ENGINE CONDITION
HIGH AND STEADY	Good
LOW AND STEADY	Loss of power in all cylinders caused possibly by late ignition or valve timing, or loss of compression due to leakage around the rings.
VERY LOW	Manifold, carburetor or cylinder head gasket leak.
NEEDLE FLUCTUATES - STEADILY AS SPEED INCREASES	A partial or complete loss of power in one or more cylinders caused by: *A leaking valve* *Cylinder head or intake manifold gasket leak* *A defect in the ignition system* *A weak valve spring*
GRADUAL DROP IN READING AT ENGINE IDLE	Excessive back pressure in the exhaust system.
INTERMITTENT FLUCTUATION	An occasional loss of power possibly caused by a defect in the ignition system or a sticking valve.
SLOW FLUCTUATION OR DRIFTING OF THE NEEDLE	Improper idle mixture adjustment, or carburetor, spacer or intake manifold gasket leak.

Manifold Vacuum Test

Operate the engine until it is normal operating temperature.

Connect the vacuum gauge to the intake manifold and test with the engine operating at idle speed, under no load conditions (see following table on next page).

Test Procedures For Engine Protection Devices



LOW OIL PRESSURE TEST PIPING ARRANGEMENT

Low Oil Pressure (Lop) Test

To test the low oil pressure Switchgage, install two needle valves, a 0-100 psi (0 - 7 kg/cm2) pressure gauge and piping as shown in the illustration. With the engine in operation,

Low Pressure Test Piping Arrangement

Simulate a low oil pressure shutdown by closing the ¼" needle valve in the oil pressure line to the Switchgage. This will trap oil pressure in the system.
Then slowly open the ¼" needle valve in the line to waste, observing the oil pressure indicated by the test gauge when the Switchgage is actuated.

If necessary, adjust the Switchgage as required ad repeat the test. After testing, immediately close the needle valve in the line waste and open the needle valve in the oil pressure line to the Switchgage.

High Water Temperature (Hwt) Test

To assure high temperature shutdown, the temperature sensor bulb should be removed from the thermostat housing and immersed in hot water. Then the water should be heated until it boils. Allow sufficient time for the sensor to actuate the control.

NOTE: *The preceding tests apply to the typical safety controls used on VR engines. If engines con tain special controls, test procedures can be obtained from Arrow Specialty Department.*

Engine Storage

Preservation of engines and generators in storage involves several basic requirements. For new engines and generators, these are as follows:

1. Protection of machined metal surfaces, cylinders, valves, bearings, and so on, from the effects of both dampness and salt or other corrosive substances in the atmosphere.

2. Protection of openings into the engine against entrance of dirt, abrasive material, and foreign matter of all types.

3. Protection of accessory equipment, including carburetors, gas regulators, magnetos, starters, generators, and fan belts against corrosion, dirt, moisture saturation and deterioration.

4. Protection of the cooling system and LPG vaporizers against freezing, rusting, or seizure.

5. Protection of a general nature against the elements: rain, snow, and extremes of temperature.

6. Protection of batteries by disconnecting and removing them to a slow charging station where they can be kept fully charged. If this is neglected, the plates can be damaged and ruined by becoming sulphated.

7. Protection of the generator or alternator by covering all openings to prevent the entry or dust, moisture, dirt, and rodents. A heavy craft paper will serve this purpose. Where these openings are in the form of screened or louvered guards or covered plates, the protective paper should be placed under these removable parts. If this is not possible a pressure sensitive tape can be used to hold the paper in position.

   Do not use masking tape - it is not suitable for this type of service and will be very difficult to remove after extended use. Application of protective paper should be on both inside and outside of large, fixed, louvered surfaces. Large open areas should have a corrugated cardboard backing for paper.

8. Protection of switchboards in the same manner as generators.

In the case of engines previously operated, additional items must be considered.

9. Protection of interior engine parts, particularly bearings, cylinder walls, and valves, against corrosion by the products of combustion combined with atmospheric moisture and corrosion by lubricating oil contaminants.

The extent of the attention given to each of the preceding points of possible damage depends on the judgment of the person in charge of the equipment. Generally speaking, the following factors should be taken into consideration before deciding how much or how little preservation is required:

1. The period of time the equipment is likely to be inoperative.

2. The severity of the weather and atmospheric conditions at the point of storage. The problems of storing equipment in a tidewater warehouse, for example, differ greatly from storage problems in a location where the air is very dry and dusty.

3. The accessibility of the equipment for periodic inspection and attention. An engine on a showroom floor that may be turned over occasionally and given periodic oiling requires less extensive treatment than engines crated and stocked in a warehouse.

CONVENTIONAL STORAGE

Storing New Engines

All VR Series engines shipped by Arrow Engine Company will be shipped with the break-in oil and corrosive inhibiting additive. Engines stored outdoors or in a humid environment may require additional preservation methods. For recommendations, contact the factory.

1. Engines in operable condition:

   A. Mix an inhibitive - type preservative oil with the engine lubricating oil in the proportions recommended by the manufacturer of the preservative oil. (With some products no mixing may be necessary.) Operate the engine until the oil is hot. Cooling water used in this run should have an inhibitor, as explained in the cooling system maintenance.

   B. Remove air cleaners from gas engines. With a manually operated sprayer, squirt can, or other means, inject preservative oil into the air intake while the engine is running. Approximately one minute is ordinarily adequate. If possible, stop the engine by "slugging" enough oil through the air intake to make it stall. Continue injecting oil until the engine stops turning.

   C. Drain oil and water while hot. If extra protection is desired, the rocker arm covers may be removed and a quantity of preservative oil poured over the rocker arm and valve mechanisms. Replace the rocker arm cover and tighten down to seal the vapor inside the cover.

D. For engines not stopped by “slugging”, remove spark plugs and squirt or spray several teaspoons of preservative oil into each combustion chamber. Coat spark plugs and reinstall.

E. Remove the distributor cap or magneto cover and apply a small amount of petroleum jelly to the polished surface of the breaker cam. Where dampness in storage is expected, magneto removal may be worthwhile.

F. Wipe the engine clean and dry. Apply wax type tape or a like material to all openings such as intake openings in air cleaners, exhaust outlets, breathers, magneto vents, and open line fittings.

G. Relieve tension on belts. This is important because continual tension on belts without the working action that occurs in normal operation causes deterioration of the rubber.

H. Apply a coating of a heavy preservative compound with a brush to all exposed-machined surfaces such as flywheels.

Engines treated in accordance with these instructions will normally be protected for one year or longer. Continual inspection, however, is the only way to determine if protection is adequate.

If possible, crank the engine by hand for one or two turns about once a month. This helps prevent seizure of water pump seals. If this is done, however, it is usually best to add more preservative oil to each cylinder.

Some types of preservative oil are not well suited to periodic engine rotation because they are scraped from the cylinder walls which are then unprotected. Other oils are not scraped away, and for this reason the operator should carefully investigate the characteristics of the oil used.

2. When the engine is not operable.

A. Open drains as required to remove oil and water,

B. Removed the spark plugs and pour or squirt about a teaspoon (5 cc) of preservative oil into each cylinder.

C. With hand or mechanically operated atomizing spray (do not use ordinary compressed air), inject preservative oil into each cylinder. Crank the engine in the normal direction about one-quarter turn and spray each cylinder again. Do this about eight times, or until the engine has been turned through two complete revolutions. The purpose of this procedure is to bring each valve into an exposed position so the preservative oil will coat it.

D. Depending on the judgement of the operator as to the severity of storage conditions, remove oil pan, valve rocker arm cover, gear cover plates, and as many points as possible where oil may be sprayed, poured, or squirted over the interior parts. Replace all plugs and covers.

E. The remaining steps are the same as listed in “E” through “I” for an operable engine.

Storing Engines That Have Been In Service

In the course of normal engine operation, residues of various combustion products such as lead and sulphur accumulate in the combustion area and in the lubricating oil. Portions of these residues combine with atmospheric moisture to from corrosive compounds. The following treatment will help reduce damage from this source:

1. Engines in operable condition:

A. Run the engine until the original oil is hot. Drain.

B. If practical, run the engine with a good flushing oil in the crankcase and drain the oil and water while still hot.

C. Refill the crankcase with preservative oil, or with the proper grade of lube oil to which an inhibitive type preservative oil has been added in the proportion recommended.

D. Carry out the previous instructions “D” through “I” under “Storing New Engines” as the circumstances indicated.

2. When the engine is not operable:

A. Carry out the instructions for an inoperable new engine.

B. If, in the judgement of the operator, storage conditions warrant, the engine should be disassembled, thoroughly cleaned, and reassembled for treatment as a new engine.

Ordinarily, this last procedure is unnecessary except in cases where fuels containing considerable sulphur have been used, or where extremely bad climatic conditions prevail.

PRESERVATION EQUIPMENT AND MATERIAL

Sprays And Atomizers

Many times it is necessary to apply protective compound under difficult field conditions. Several simple tools can be used to atomize preservative oil and force it into the manifolds and combustion chambers. One of these is a manually operated atomizing gun used ordinarily to lubricate inaccessible points on car and truck chassis. Another is a hand operated pump-type sprayer with a pointed discharge nozzle (commonly used with insecticides). If desired, small oil pumps can be rigged with a motor drive to make a convenient spray unit of the mechanical pressure type. In almost all cases, the air available from shop compressor lines carries too much moisture to be safe for this purpose. Do not use high-pressure air from this source.

Heating Of Preservative Compounds

Many preservative compounds are most effective when heated before application. If possible the engine should be warmed prior to applying preservatives. Heating the preservative oils reduces their viscosity so as to gain penetration into accessible areas. In addition, the hot compound reduces the moisture film at the metal surface and thus avoids trapping moisture under the preservative layer.

WARNING

Generally speaking, such heating is confined to 200°F. (93° C.) or less. These temperatures are easily reached by placing the preservative container in heated water. Direct heating presents a dangerous and unnecessary fire hazard.

PREPARING THE ENGINE FOR OPERATION AFTER STORAGE

The steps needed to bring an engine into active service after storage in accordance with these instructions are about the same as those normally carried out on any new engine. These are inspection, checking for free rotation, adequate cooling water or antifreeze, ample lubricating oil of the correct type and viscosity, and proper adjustments.

In addition, accumulated dust and dirt should be wiped or washed from the exterior before removing the covers over the engine openings.

Removal of installed protection should occur upon normal inspection of the engine, generator, and switchgear interiors prior to start-up. Partial removal may be necessary in the course of installation, but this should be kept at a minimum. Engines that have not been rotated for some time should be oiled through the spark plug openings and cranked by hand or with the starting equipment before they are run. Any resistance to free cranking should be investigated; rust and corrosion can cause severe seizure that cannot be forced clear without engine damage.

CAUTION

All generators and switchgear which have been stored must be checked for insulation resistance with a "Megger" prior to being put into service. The megger used should produce 500 V.D.C. Disconnect the voltage regulator, rotating diodes, suppressors and any other solid state devices which may be connected to the stator or rotor windings. The megger value should be: operating voltage ÷ 1000 + 1 (i.e., machine voltage of 480 V.A.C. ÷ 1000 = .480 - 1=1.480 megohms). If any circuit to ground measures less than the calculated value, consult the Service Department for necessary corrective measures.

Never attempt to start an engine that has been stored without first cranking it over with the spark plugs out. Spurting oil, water or preservative compound from these openings could lead to a possible hydraulic lock if an attempt is made to operate the engine. Continue to crank the engine with the starter or by hand until liquid is no longer rejected from any openings. Inspect intake passages and manifolds for thickened preservative oil. Oil accumulated in this condition may melt when the engine warms up and cause a runaway.

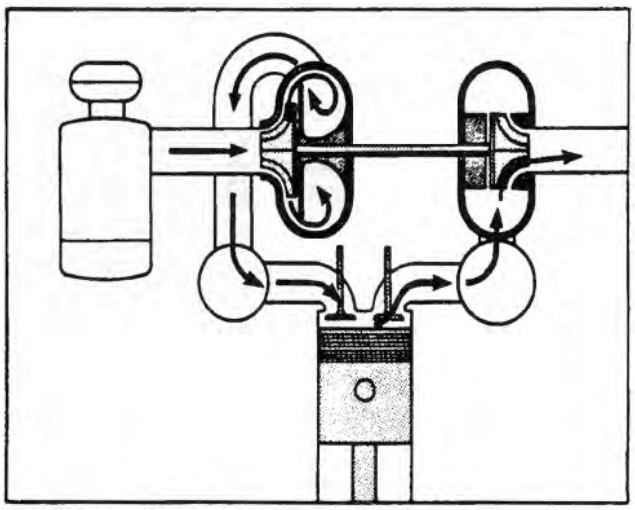
Turbocharged Engines

The following information is supplied as a general guide to understanding the operation of turbocharged engines. It should not be construed as complete engineering or service data.

As shown in the accompanying schematic diagram, the exhaust-driven turbine and its attached compressor are not connected to the working parts of the engine in any physical manner with the exception of the exhaust and intake manifolds and the oil lines. The turbocharger will not be troubled by gear train, belt, or other mechanical drive engine troubles. Moreover, since the supply of hot gases under high velocity supplied to the exhaust turbine is a reflection of the engine speed and load, the turbocharger output is closely matched to the engine air requirements. The schematic diagram illustrates how the high speed compressor driven by the exhaust turbine provides additional air for the combustion process and thus materially boosts the power output of the engine. The exhaust back pressure is actually very slight since it is the velocity of the gas and its unused energy that is put to work.

The turbine or driving member of the unit is made of a special heat resisting alloy. It is surrounded by a housing which directs the flow of exhaust gases onto the turbine blades. On the opposite end of the same shaft, which supports the compressor, the precision-made aluminum alloy impeller operates within a surrounding diffuser housing. Both turbine and compressor turn at the same speed. The full load speed of the two units together with their shaft is approximately 90,000 (ninety thousand) rpm. For this reason, these parts must be in a close to perfect balance as possible. Not even the slightest filing, scraping, sandblasting, drilling, cleaning or repair procedure that could conceivably remove or add metal can be permitted. A very small amount of unbalance can cause severe damage at the speeds involved.

The possibility of excessive muffling or unusually restrictive exhaust pipe installations should always be considered when checking turbocharger efficiency. In general, the turbocharger is an effective muffling device. When additional muffling is required, contact your distributor or Arrow Engine Company.



Since the turbocharger is basically a centrifugal air pump driven by a gas turbine, anything which causes leakage or impedes the gas flow will reduce the efficiency and power output. In all cases where engine turbocharging and power output seem to be less than normal, check first for possible leaks in the connections at the intake manifold and exhaust manifold. Very slight leaks are sometimes serious contributors to low engine efficiency. The next point to check under low performance conditions would be the possibility of a partially clogged air cleaner. It is essential that the air cleaners be as efficient as possible to prevent substantial amounts of dirt from reaching the impeller. Turbocharged engines draw much more air than naturally aspirated engines draw. Therefore, proper and regular air cleaner maintenance is a must.

Since even the most efficient air cleaner is certain to pass a slight amount of fine dirt, it is possible for some of this material to collect on the impeller if sufficient oil or other binder material is present. This can cause impeller imbalance and will definitely reduce efficiency. Depending on conditions, a periodic program should be established for removal of the air inlet connection at the compressor to inspect for dirt accumulation on the compressor surfaces. When and if dirt is found, never scrape away such material with a screwdriver, dirty rag, sandpaper, or emery or steel wool. Such techniques are certain to damage the compressor. Clean with a clean, soft brush and solvent. Cleaning must be complete and even all the way around

Turbocharger Preventive Maintenance

All air duct and gasket connections should be routinely checked for tightness and leaks. Repair and loose or leaking connection immediately. Ingestion of dirt into the compressor can cause severe wear and damage to the turbocharger as well as the engine.

Leaking pressure joints cause loss of power and engine overheating. Excessive dirt buildup in the compressor can also cause a considerable loss of power and overheating. Accumulations should be removed with a non-caustic cleaning solvent. Observe schedule lube oil change intervals to ensure normal service life of the turbocharger bearings. Use the recommended lube oil and genuine Arrow replacement filters. Turbocharged engines should be idled for several minutes after starting and before shutdown to prevent "oil lag" failures to turbocharger bearings. This is particularly important during cold weather or when the equipment has not been in use for extended periods.

NOTE: *Because the turbine side of the turbocharger can flex when it is hot, care should be taken to ensure that the weight of the exaust system is not carried by the turbocharger. The muffler and it's piping should be supported independently and connected to the turbocharger by a flexible coupling.*

TROUBLESHOOTING

A well planned troubleshooting program can help determine the cause or causes of unsatisfactory engine operation and help point out the action needed to correct the problem. A working knowledge of how engine systems work, combined with the trouble shooting chart in this unit and current indications from the engine instrument panel, provide the best background for good trouble shooting.

OPERATING CONTROLS

Most VR Series engines are equipped with the following operating controls (see illustration).

INSTRUMENT PANEL

1. Starter Receptacle - Optional
2. Throttle
3. Ammeter - Optional
4. Oil Pressure
5. Starter Switch
6. Water Temperature
7. Ignition Switch
8. Tachometer - Optional
9. Hour Meter - Optional

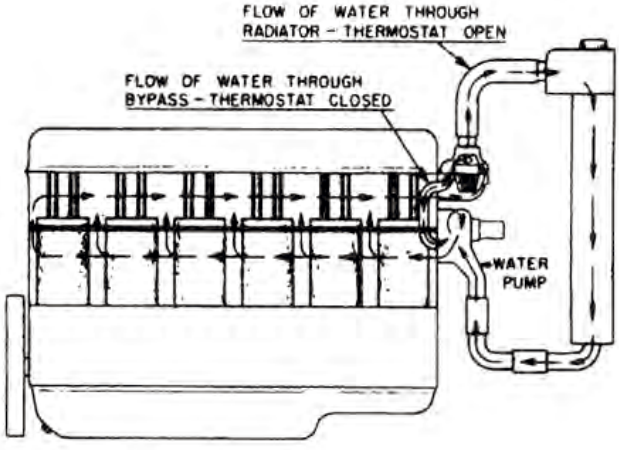
Electrical System

The engine electrical system consists of a battery, heavy-duty starter and alternator, regulating devices, switches, and circuits similar to automotive installations. The engine is started by closing a circuit from the battery to the starter. The starting motor solenoid provides positive engagement of the pinion before cranking. After cranking is completed and the engine starts, the solenoid disengages. The alternator recharges the battery. Cutouts and regulators control the alternator's output and protect the system from reverse currents and excessive charging.

Arrow Engine Company supplies engines with negatively grounded electrical equipment only. This standardization of electrical system polarity is common for most equipment manufacturers, and this increases compatibility between supplied electrical equipment and that supplied by the equipment builder.

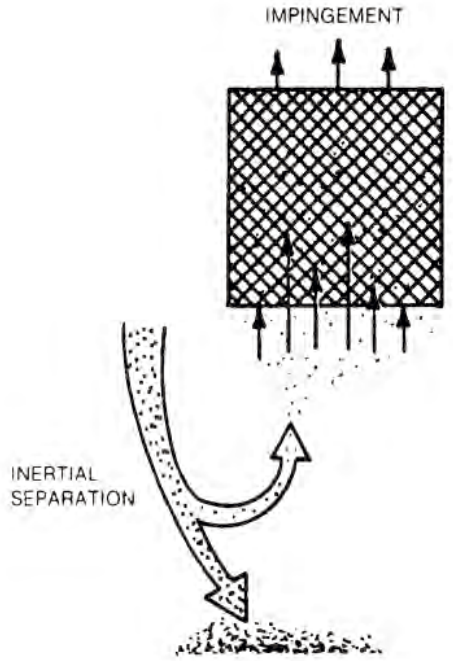
Cooling System

A pressure circulating cooling system is used on the VR Series engines. The water enters the water pump inlet on the left side of the engine. The centrifugal pump pulls this supply of cool water through the pump body and forces it into a passage leading directly into the engine cylinder jacket. The water enters the engine just above the lower end of the cylinder sleeves. From here, the water flow is directed around the cylinder sleeves until it passes upward from the crankcase and into the passages in the cylinder heads. These passages are carefully designed to allow the cooling water to have access to the areas around the valve seats and valve guides. Water is collected from the cylinder head and enters the thermostat housing at the forward end. The thermostat regulates the engine temperature by automatically controlling the amount of coolant passing through the cooler or radiator core. Back pressure at the water outlet must not exceed 5 psi. (.35 kg/cm2).



Air Intake System

With the exception of adequate supplies of clean oil and water, probably no other single service item contributes as much to engine life as a properly working air cleaner. This is particularly true under dusty and agricultural operating conditions, but surprising amounts of abrasive dirt are present in even the cleanest engine room. If carried into the engine through the air inlet, such abrasives would rapidly wear away cylinder walls, valve stems, bearings and other working parts.



TWO STAGE AIR CLEANER

Even though the dust particles are small, they can cause great damage. It is mandatory that air inlet connections be kept tight to avoid taking in unfiltered air beyond the air cleaner.

The purpose of all air cleaners is to trap dirt and grit. The element must be cleared or changed as dirt accumulates. This could be several times each day if conditions are especially bad.

Exhaust System

Efficient removal of engine exhaust is very important. An engine consumes an incredible amount of air. After combustion takes place, the products of combustion must be pushed out of the cylinders, manifolds and exhaust piping. Every possible provision must be made to minimize the restriction or back pressure in an exhaust system.

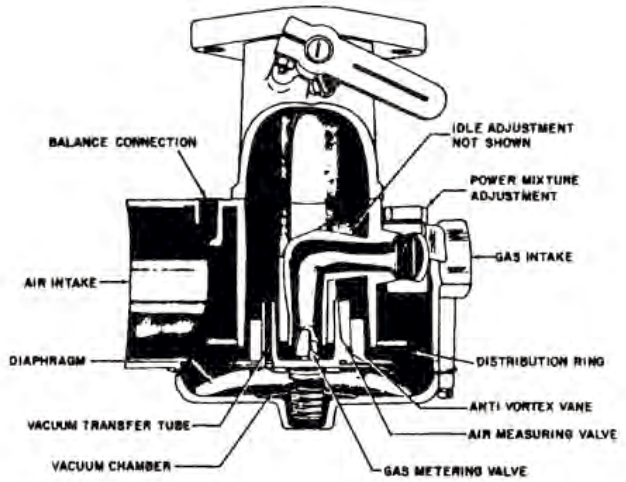
Some of the adverse effects of excessive back pressure are loss of power, smoking, poor fuel economy, excessive valve temperatures, premature valve wear, and jacket water overheating.

The exhaust system of an engine, particularly when using long exhaust pipes, can accumulate condensed moisture. If this moisture is allowed to run back through the piping and into the engine after shutdown, rusting and sticking of valves, rings, etc. and the possibility of a hydraulic “lock” become serious. Always provide a condensate trap and drain at some low point ahead of the engine manifolds.

FUEL SYSTEMS

Natural, Lp, And Digester Gas Carburetion

The Arrow carburetor is structurally simple, consisting of a main body with a conventional butterfly throttle valve and a diaphragm operated gas metering valve. The amount of air going to the engine is measured by an airflow measuring valve. This valve rises in direct proportion to the air volume passing through it. The gas metering valve is mechanically fixed to the air measuring valve. As the air valve rises, the gas valve rises with it, thus opening the gas passage proportionately to the amount of air entering the engine. This establishes and holds a definite fuel/air ratio throughout the engine operating range.



Ignition Systems

Smooth combustion requires fuel ignition within the cylinders at finely defined intervals. VRG Series engines are equipped with a magneto or CD-1 ignition to provide the precisely defined firing pattern.

There is little difference between a magneto and a distributor. A distributor depends upon an alternator and storage battery for its primary current; the magneto uses a primary current generated within itself by rotation of permanent magnets between the pole shoes.

Distributors are driven by a tang which is mated with a slot in the upper face of the oil pump drive gear. CD-1 maintains set timing through out the RPM range.

Lubrication System

The lubrication system on every VR220/330 engine uses a gear-type oil pump and a full flow filter. The oil cooler is optional on all engines.

The suction produced on the inlet side of the oil pump draws the oil through the slotted pickup tube (which screens the oil) and into the pump inlet. The oil is discharged under pressure at the top of the pump.

Oil gallery pressure is controlled by the adjustable pressure relief valve, located in the oil pump body. Correct oil pressure is 40-50 psi (2.81 - 3.52kg/cm2) at 2600 rpm. To adjust pressure, the oil pan must be removed to get at the pump. Turn the relief valve adjusting screw in to increase oil pressure; back it out to decrease pressure.

All the oil then passes through the full flow filter (and cooler, if used) and into the main oil gallery. If the filter is clogged and excessive pressure builds up, a bypass valve in the filter allows oil to go directly to the gallery.

Drilled passages carry the oil from the gallery to the crankshaft main bearings, to the camshaft bushings and to the balancer. (The balancer is available as an option on four cylinder engines only. If the balancer is not used, the balancer oil passageway in the bottom of the crankcase, near the right front main bearing cap, must be closed off with a plug.)

Oil from the crankshaft main journals travels through drilled passages and lubricates the crankshaft pin bearings. The piston pin bushings are lubricated by oil flowing from the crankpin bearing through a drilled passage in each connecting rod.

Oil flows through a notch in the bearing shell of the front main bearing and into a short passage that intersects with the left mounting screw hole for the bearing cap. Oil travels around the counterbore relief of the screw threads and through a crankcase passage to the idler gear spindle. Both of the passages and the mounting screw hole must be clean; otherwise, the idler fear bushing will not get enough oil.

The idler gear spindle has an annulus cut into its base. Oil enters the annulus, travels through the shaft and lubricates the bushing. The end of the spindle must be closed off with a pipe plug; otherwise, the gear bushing will not get a pressurized supply of oil and engine oil pressure will drop.

Oil goes to the idler gear and then to the governor though an external connection.

Within the front gear case, oil splash and oil mist lubricate all the meshing gear teeth, the fuel injection and transfer pump drives, and the magneto drive.

The rocker arm assembly is lubricated by oil that flows under metered pressure through a drilled crankcase passageway coming from the number two camshaft bushing. This oil then drains back to the sump through cylinder head and crankcase drain holes, simultaneously lubricating the valve lifters and camshaft lobes.

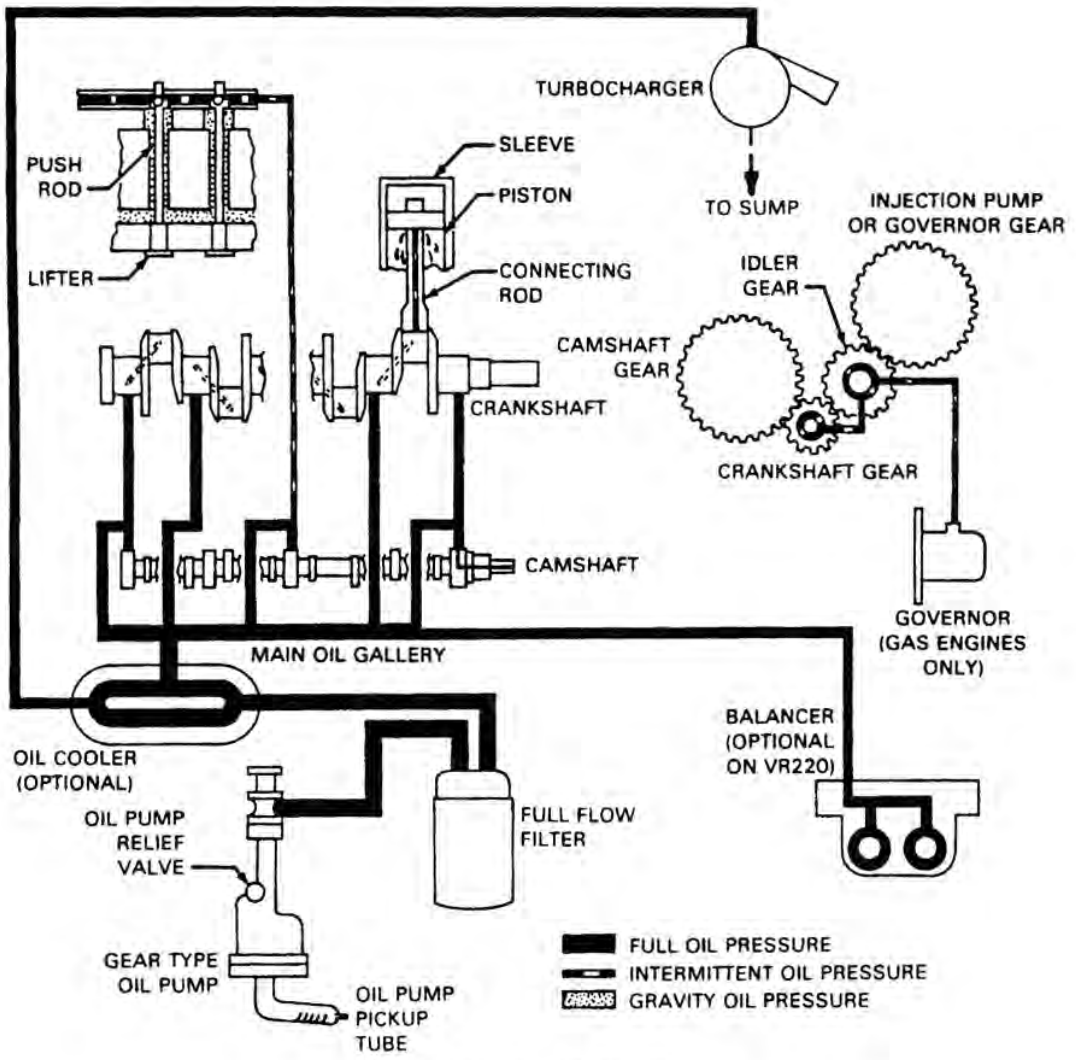
The use of an oil cooler is optional. Oil goes from the filter, into the cooler and then into the gallery.

The turbocharger is lubricated by a full pressure oil line coming from the base of filter adapter. After lubricating and cooling the turbocharger, the oil drains back through the crankcase and into the oil pan.

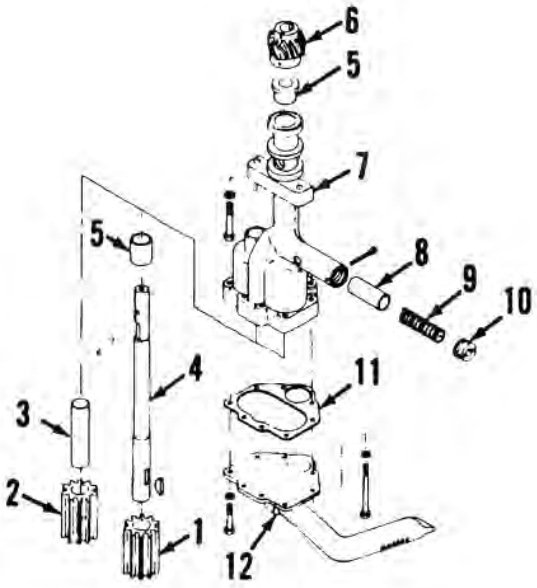
On engines with the optional hydraulic pump drive on the back of the front fear case, a camshaft outboard bushing is provided in the gear cover to support the camshaft front extension.Oil flows from the front camshaft bushing, through drilled passages in the camshaft and then to the outboard bushing. The end of the camshaft front extension must be sealed with a pipe plug. The camshaft thrust plate on the crankcase front end is also lubricated from the front camshaft bushing.

On four cylinder engines equipped with the optional balancer, oil under pressure flows down from the gallery and through a vertical passage at the right front of the crankcase. The pipe plug in this hole must be removed on balancer-equipped engines. Oil enters the front end of the balancer cradle, where it lubricates the bushing of the drive gear spindle and the front bushings of both balancer shafts. Drilled passageways in the balancer shafts carry the oil to the rear bushings of the balancer shafts.

Depending on the engine configuration and application, you may add oil to the engine through the dipstick tube, through the rocker arm cover, in the left front or left rear of the engine, or in the right rear or right front of the engine.



LUBRICATION SCHEMATIC



OIL PUMP
1. DRIVER GEAR
2. IDLER GEAR
3. IDLER SHAFT
4. DRIVE SHAFT
5. BUSHING
6. DRIVE GEAR
7. PUMP BODY
8. RELIEF VALVE PLUNGER
9. RELIEF VALVE SPRING
10. ADJUSTING SCREW
11. GASKET
12. OIL PUMP COVER ASSEMBLY

TYPICAL VR OIL PUMP

Balancer (Vr220 Only)

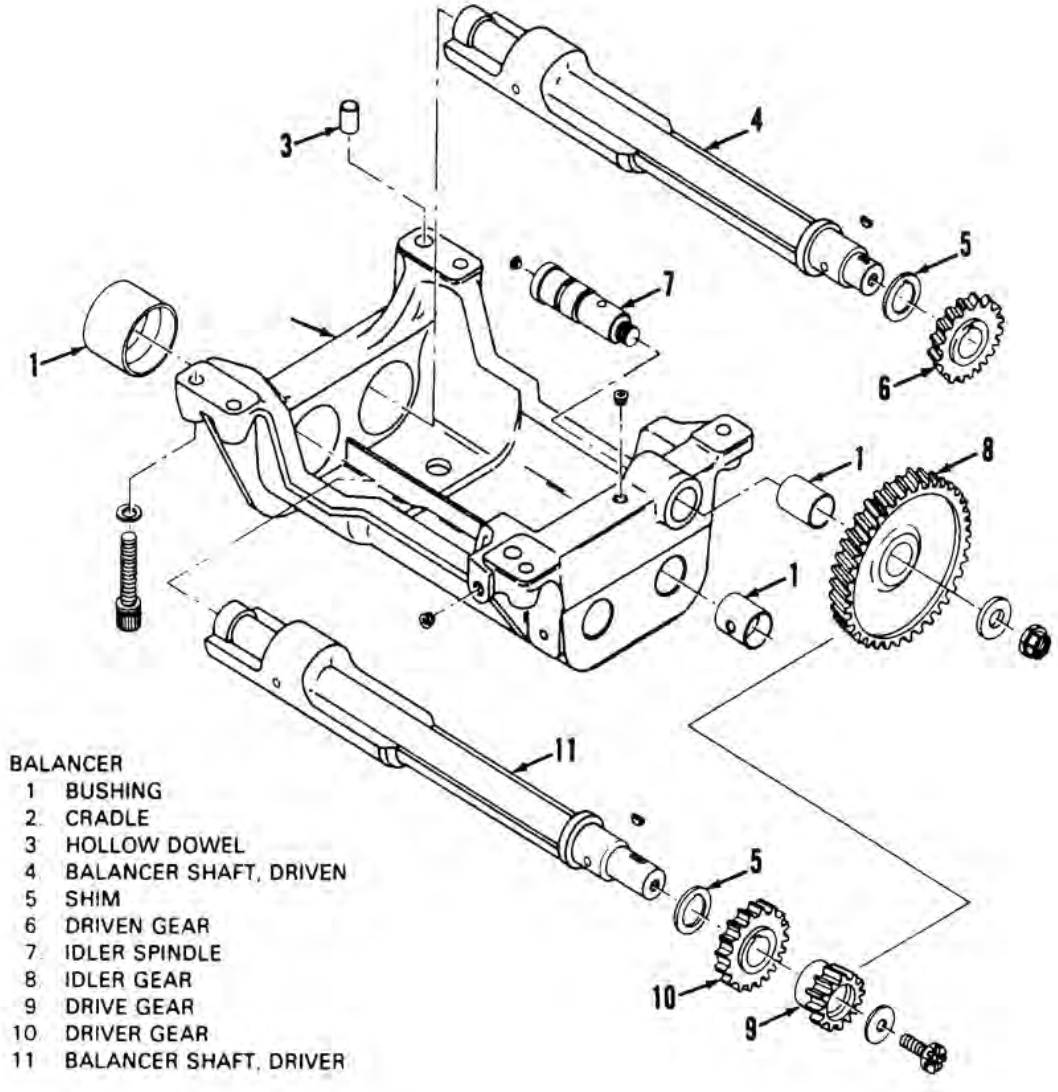
The balancer receives oil that flows down from the main oil gallery and through a vertical passage at the front of the crankcase. On engines without balancers, the bottom of this passageway is plugged. If the balancer is being used, the pipe plug must be removed in order for the balancer to get oil.

The back end of the balancer idler spindle is closed off with a pipe plug, and there are two more pipe plugs sealing oil passages in the front end of the balancer cradle. All plugs must be in place as these are full oil pressure passages.

The balancer must be correctly timed to the engine. The “B” that is stamped on the face of the balancer idler gear must be aligned with the “B” that is no the face of the crankshaft gear. The “P” that is stamped on the idler gear must be aligned with the “P” on the balancer driven pinion. And the “G” that is on the face of the balancer driven gear must be aligned with the “G” on the balancer driven gear. You should not have to retime the pinion driven gear or driver gear unless the balancer has been completely disassembled. If you have removed the balancer as an assembly, you should make sure that the balancer idler gear is timed to the crankshaft gear during reinstallation.

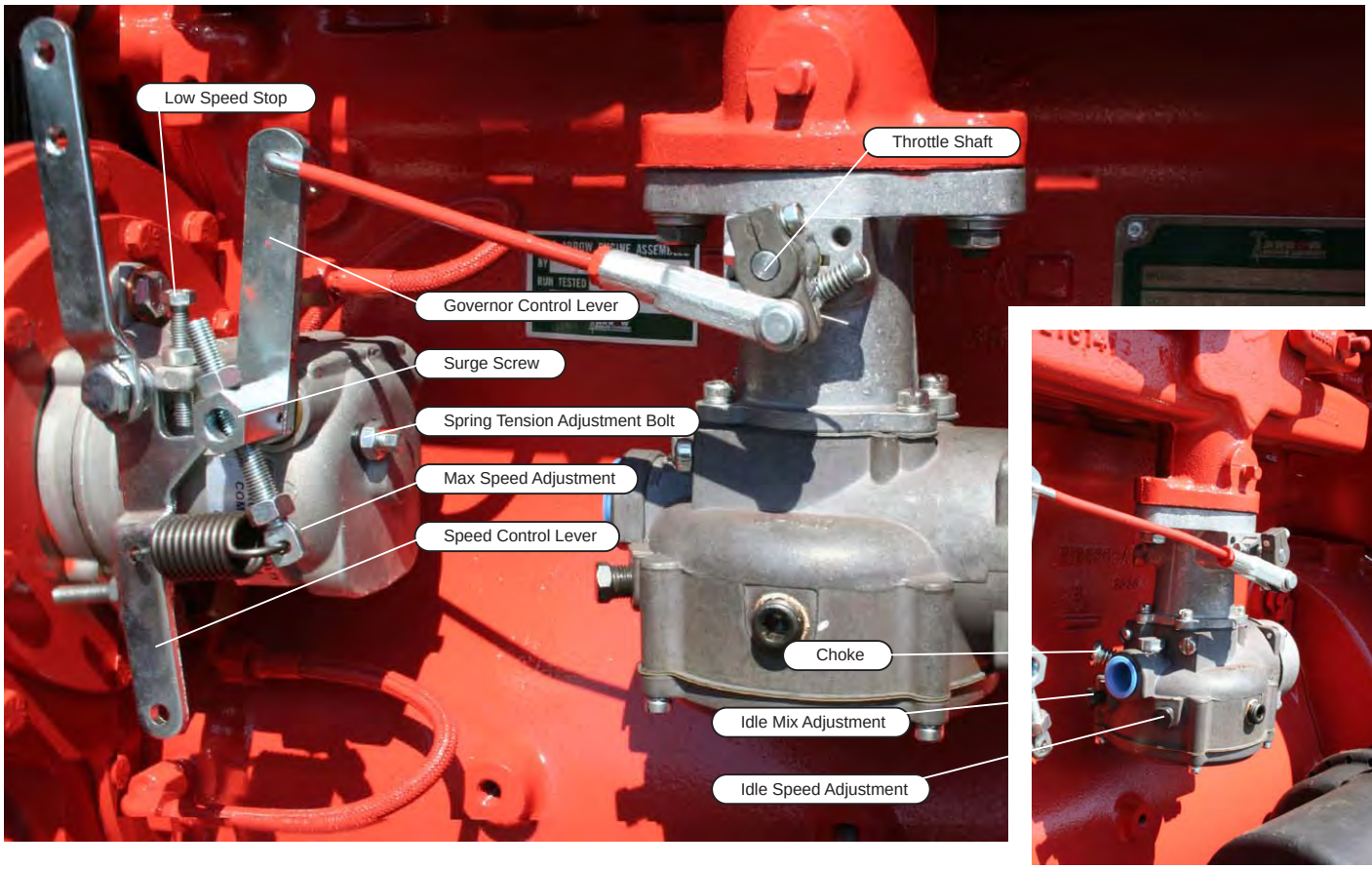
CAUTION

If balancer is removed from the engine permanently, the oil supply hole in the underside of the crankcase must be plugged to prevent oil pressure loss.



BALANCER
1 BUSHING
2 CRADLE
3 HOLLOW DOWEL
4 BALANCER SHAFT, DRIVEN
5 SHIM
6 DRIVEN GEAR
7 IDLER SPINDLE
8 IDLER GEAR
9 DRIVE GEAR
10 DRIVER GEAR
11 BALANCER SHAFT, DRIVER

BALANCER



Mechanical Governors

Mechanical centrifugal type governors are used on VR gas and gasoline engines with a variable speed "swinging spring" adaptation. Two weights, driven directly from the engine gear train, respond to variations in engine speed by moving inward or outward from the governor shaft. This movement is transmitted to the governor weight shifter lever through a pilot bearing sliding on the governor shaft. From the shifter lever the movement is carried to the throttle valve in the carburetor by a series of linkages. On centrifugal governors, as the engine slows down under an applied load, the weight moves inward due to the reduced centrifugal force. Through the linkage system, this weight movement causes the throttle valve to open and admit more fuel and air to the engine, thus restoring normal loaded speed.

The governor also acts as a protective device to prevent engine damage due to overspeed. Here, as the speed increases towards that speed established as the maximum, the weights move outward under the increased centrifugal force. This movement is opposed by the governor spring. When the force acting on the weights is balanced by the spring tension the governor linkage stabilizes. At this point the amounts of fuel and air entering the engine are held to those needed for the selected maximum speed and no more.

An adjustable eye bolt with locking nuts can also be used for closer regulation within the variable speed range.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
CRANKSHAFT CANNOT BE BARRED OVER **CAUTION:** *DO NOT attempt to rotate crankshaft with starter.*	Seized piston	Replace piston assembly and possibly sleeve. Determine cause of seizure-insufficient ring gap, insufficient lubrication, inadequate cooling, or overload.
	Coolant or obstruction in cylinder	**CAUTION:** *Remove spark plugs and crank engine to vent cylinders of accumulated coolant.*
	Cracked head	Replace head.
	Cracked sleeve	Replace sleeve.
	Blown head gasket	Replace head gasket.
	BEARINGS TOO TIGHT	
	High spots on bearings	Replace bearings.
	Improper torque	Loosen bearing cap and re-torque.
	Main bearing caps installed out of location.	Check each bearing cap. Place in proper location.
	Load not disengaged from engine.	Disengage load.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE WILL CRANK BUT WILL NOT START	ON/OFF switch in OFF position or defective.	Place switch in ON position or replace switch.
	INSUFFICIENT CRANKING SPEED	
	A. Run-down battery or electric starter system malfunction. B. Lube oil viscosity too high.	A. Charge or replace battery; check stater system. B. Change to lower viscosity as recommended in PREVENTIVE MAINTENANCE.
	Mistimed or faulty ignition system.	Re-time, repair or replace components as required.
	POOR COMPRESSION	
	A. Worn rings B. Leaking valves C. Leaking head gasket	A. Replace rings. B. Recondition head and valves. C. Replace head gasket.
	FUEL SYSTEM INOPERATIVE	
	A. Water in fuel. B. Insufficient fuel supply. C. Ruptured gas pressure regulator diaphragm. D. Stiff gas carburetor diaphragm or worn air-gas valve assembly. E. Bent gas pressure regulator control rod.	A. Drain water at strainers and tank. B. Check gas pressure and carburetor **adjustments.** **C. Replace diaphragm.** **D. Replace air-gas valve assembly.** E. Replace control rod.
	GOVERNOR INOPERATIVE OR BINDING CONTROL / LINKAGE	
	A. Linkage dirty. B. Linkage broken. C. Linkage pivot points.	A. Clean. B. Repair linkage. C. Re-adjust or replace pivot point bearing surfaces.
	Clogged air cleaner element.	Remove and clean.
	Safety shutdown control not re-set.	Re-set safety shutdown control.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE STOPS SUDDENLY	**FUEL**	
	A. Water in fuel. B. Insufficient fuel supply. C. Loose fuel control linkage. D. Clogged fuel supply line.	A. Drain water at tank. B. Check gas pressure and carburetor adjustments. C. Readjustment and tighten. D. Replace line.
	Obstructed exhaust manifold.	Determine and correct cause of obstruction.
	Faulty ignition system.	Repair or replace components as required.
	Clogged air cleaner element.	Remove and clean.
	Engine over speed causes safety control to shut down engine.	Determine and correct cause of overspeed.
	Excessive load causes engine to stall.	Determine and correct cause of over load.
	PISTON SEIZURE	
	A. Insufficient ring gap (applicable only immediately after overhaul.) B. Insufficient lubrication. C. Insufficient cooling.	A. Replace scored piston, sleeve and rings. Adjust ring gap. B. Replace scored piston, sleeve and rings. Clean oil passages and / or determine cause of lack of lubrication. C. Replace scored piston, sleeve and rings. Clean and / or fill cooling system.
	Bearing seizure: Main, connecting rod, piston pin or camshaft bearings	Replace bearings. Clean up or replace crank-shaft, camshaft, or piston pin as required.
	Lack of lubrication.	Check lube oil system. Correct cause.
	Dirt in lube oil,	Check lube oil filter and replace if needed.
	Obstruction in cylinder,	Replace all parts that failed.
	Low oil pressure causes safety control to shut down,	Inspect lubricating oil system and components. Correct cause.
	High coolant temperature causes safety control to shut down engine,	Inspect cooling system and components. Correct cause.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE POWER LOSS	**LOW COMPRESSION PRESSURE**	
	A. Leaking head gasket.	A. Replace head gasket; inspect for warped cylinder head and / or crankcase. Replace if necessary.
	B. Leaking exhaust, intake valves.	B. Recondition head and valves.
	C. Worn rings (excessive blow-by.)	C. Replace rings.
	D. Worn piston sleeves.	D. Replace if necessary.
	E. Cracked piston.	E. Replace.
	F. Cracked cylinder head.	F. Replace.
	G. Misadjusted intake and exhaust valve (if recently overhauled.)	G. Adjust valves.
	H. Dirty air cleaner element.	H. Clean or replace.
	I. Restriction in intake and / or exhaust system.	I. Check for obstruction.
	J. Turbocharger malfunction.	J. Repair or replace.
	INSUFFICIENT FUEL	
	A. Cracked fuel lines / filters.	A. Replace cracked lines and damaged filters.
	B. Worn fuel supply pump.	B. Overhaul or replace.
	C. Low gas pressure.	C. Check gas fuel system.
	Excessive exhaust system back pressure.	Correct as required.
	Dirty air cleaner element.	Remove and clean or replace.
	Ignition timed improperly.	Re-time.
	ENGINE MISFIRING	
	A. Incorrect carburetor or regulator adjustment.	A. Re-adjust.
	B. Faulty ignition system .	B. Repair or replace components as required.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
LOW OR FLUCTUATING LUBRICATING OIL PRESSURE **CAUTION:** *Shut down engine immediately!*	Insufficient oil.	Add oil as required.
	Gauge inaccurate.	Compare to master gauge. Replace gauge.
	Oil gauge line plugged.	Replace gauge line.
	Engine operated at angles in excess of maximum safe tilt angles.	Operate within maximum safe tilt angles.
	Oil pump pressure regulating valve stuck in open position.	Turn valve adjusting screw in to increase pressure to 40 - 50 psi (2.81 - 3.52 kg/cm²) @ 2600 rpm.
	Lubricating oil pressure regulating valve stuck in open position.	Free valve.
	Lube oil filter plugged.	Change oil filter.
	Worn lubricating oil pump.	Repair or replace pump.
	Worn bearings (connecting rod, main, and camshaft.)	Replace worn bearings.
	Cracked or leaking lubricating oil piping.	Repair or replace piping.
	Lubricating oil of low viscosity.	Change to higher viscosity oil, as recommended in PREVENTIVE MAINTENANCE.
	Lubricating oil foaming.	Use oil grade recommended in PREVENTIVE MAINTENANCE. Check for water leaks into oil.
	Clogged oil pickup tube.	Remove and clean oil pickup tube.
	Clogged or corroded oil cooler.	Inspect and clean cooler.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE WILL NOT REACH RATED SPEED	Ignition not properly timed.	Re-time.
	Carburetor improperly adjusted.	Re-adjust.
	Engine overloaded.	Determine and correct cause of overload.
	Tachometer inaccurate.	Calibrate or replace tachometer.
	Insufficient fuel supply.	Check fuel supply system.
	Governor misadjusted or faulty.	Readjust or repair.
	Restricted air intake.	Correct cause.
	Turbocharger malfunction.	Repair or replace.

SYMPTOM	PROBABLE CAUSE	REMEDY
ENGINE HUNTS OR SURGES	Misadjusted governor surge screw.	Adjust.
	Governor linkage sticky or sloppy.	Remove all dirt and burrs from linkage. Realign and re-set.
	Turbocharger malfunction.	Repair or replace.

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH LUBRICATING OIL PRESSURE	Gauge inaccurate Compare to master gauge - Lubricating oil temperature too low.	Replace gauge / Raise temperature.
	Oil pressure regulating valve stuck in closed position.	Free valve.
	Oil pump pressure regulating valve set too high.	Back valve adjusting screw out to lower pressure to 40 - 50 psi (2.81 - 3.52 kg/cm² @ 2600 rpm.
	Lubricating oil of high viscosity.	Change to lower viscosity oil as recommended in PREVENTIVE MAINTENANCE.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
LOW COOLING WATER TEMPERATURE	Gauge inaccurate.	Compare to master gauge. Replace gauge.
	Inoperative thermostat.	Replace thermostat.

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH COOLING WATER TEMPERATURE **CAUTION:** *Cool engine slowly.*	Gauge inaccurate.	Compare to master gauge.
	Cooling system is air bound.	Purge air from cooling system.
	Low coolant level.	Fill cooling system.
	Worn water pump.	Replace or overhaul pump.
	Frozen coolant.	Completely thaw cooling system before re-starting engine.
	Engine overloaded.	Determine and correct cause of overload.
	Poor coolant circulation.	Check entire cooling system.
	Blown head gasket.	Replace head gasket.
	Insufficient circulation of air (radiator cooling.)	Correct as required.
	Cracked head.	Replace head.
	Loose water pump or fan drive belts.	Tighten or replace drive belts.
	Cracked sleeve.	Replace sleeve.
	Inoperative thermostat.	Replace thermostat.
	Late ignition.	Re-time.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH LUBRICATING OIL CONSUMPTION	Oil leaks in lubricating oil system	Find and repair leaks
	Lube oil of low viscosity	Change to recommended viscosity for operating temperatures in PREVENTIVE MAINTENANCE
	Leaking oil seal(s): rear and/or front	Change seal(s)
	Worn intake valve guides	Change head; renew guides, or valve stem seals
	Turbocharger seal damaged	Repair or replace
	Stuck/worn piston ring	Replace rings
	Turbocharger and drain restricted	Repair or replace
	One or more pistons with rings upside down (if recently over-hauled)	Remove piston; correct position of rings
	Excessive connecting rod bearing running clearance	Replace bearings
	Crankcase breather plugged	Clean breather

SYMPTOM	PROBABLE CAUSE	REMEDY
LUBRICATING OIL CONTAMINATED **CAUTION:** *Change oil.*	**LUBRICATING OIL CONTAMINATED WITH WATER**	
	A. Sleeve seals leaking or sleeve cracked	A. Replace sleeve and/or O-rings
	B. Cracked crankcase	B. Replace crankcase
	LUBRICATING OIL CONTAMINATED WITH DIRT	
	A. Lube oil filter bypass valve opening because filter is plugged	A. Replace filter
	B. Lube oil filter punctured	B. Replace filter
	C. Air cleaner punctured.	C. Replace air cleaner element

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
EXCESSIVE VIBRATION **CAUTION:** *STOP engine at once - investigate cause.*	**FOUNDATION BOLTS**	
	A. Loose. B. Cracked.	A . Torque. B. Replace bolts. Torque all bolts.
	Vibration damper loose or failed (VR330 engines only.)	Replace and re-torque bolts. Replace damper.
	Misfiring ignition system.	Repair or replace components as required.
	CRANKSHAFT	
	A. Cracked. B. Main bearing bolts loose.	A. Conduct a complete investigation of entire engine for any damage. B. Determine reason for loosening. Investigate the entire lower crankcase before torquing and subjecting engine to use. Replace main bearing bolts.
	Damaged or mistimed balancer (VR220 engines only.)	Reparir or replace.
	Loose flywheel.	Replace cap screws and / or torque as required.

SYMPTOM	PROBABLE CAUSE	REMEDY
BLACK EXHAUST	**INSUFFICIENT INTAKE AIR**	
	A. Air cleaner element clogged. B. Engine overloaded.	A . Clean and repair. B. Determine and correct cause of overload.
	LOW COMPRESSION	
	A. Insufficient valve clearance. B. Burned valves. C. Worn/stuck rings and sleeves.	A. Re-set valves. B. Replace or overhaul head. C. Overhaul.
	Over-rich fuel / air mixture.	Readjust.
	Turbocharger seal leakage.	Repair or replace.
	Dirt buildup in turbocharger compressor housing.	Repair or replace.
	Carbon buildup behind turbine wheel.	Repair or replace.
	Excessive back pressure.	Reduce back pressure.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH LUBRICATING OIL TEMPERATURE	Engine overload.	Determine and correct cause of overload.
	High cooling water temperature.	See **"High Cooling Water Temperature"** table chart for causes.
	Low lubricating oil pressure.	See **"Low Lubricating Oil Pressure"** chart for causes.
	Clogged or corroded oil cooler.	Inspect and clean oil cooler.

SYMPTOM	PROBABLE CAUSE	REMEDY
KNOCKING OR UNUSUAL NOISES	Low octane fuel.	Change to higher octane fuel.
	Engine overloaded.	Determine and correct cause of overload.
	Insufficient oil to balancer (VR200 engines only.)	Check oil passage to balancer.
	Defective or mistimed balancer (VR220 engines only.)	Repair or replace.
	Turbocharger seal leakage.	Repair or replace.
	Dirt buildup in turbocharger compressor housing.	Repair or replace.
	Carbon buildup behind turbine wheel.	Repair or replace.
	Insufficient oil to idler gear.	Clean oil passage by front main bearing cap (see description under "Lubrication System".) End of idler gear spindle must be plugged.
	Overly advanced ignition timing.	Re-time.
	Loose bearings (failed.)	Replace bearings.
	Loose piston pins (failed.)	Replace piston pins and/or pin bushings as required.
	Damaged or excessively worn accessory drives.	Repair or replace components as required.
	Excessive crankshaft end play.	Replace main thrust bearing.
	Excessive valve clearance.	Readjust valve clearance.
	Sticking valve or rocker arms.	Free up or replace.
	Misfitted or excessively worn timing gears.	Replace.

TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	REMEDY
EXCESSIVE FUEL CONSUMPTION	Carburetor adjusted over-rich.	Readjust.
	Leaks in fuel system.	Repair as required.
	Faulty ignition system.	Repair of replace components as required.
	Late ignition timing.	Re-time.
	Engine overload.	Determine and correct cause of overload.
	Poor compression.	Determine cause(s) and repair.
	Improper matching or torque converter to engine and load.	Replace torque converter.

SYMPTOM	PROBABLE CAUSE	REMEDY
LOW GAS PRESSURE	Incorrectly adjusted gas regulator.	Readjust.
	Insufficient line pressure.	Increase line pressure.
	Incorrect orifice and /or spring in gas regulator.	Replace orifice and/or spring.
	Undersize gas regulator.	Replace with gas regulator of adequate size.
	Undersized piping.	Replace with piping of adequate size.
	Gas regulator mounted too far from engine.	Remount gas regulator as close to the carburetor as possible.

SYMPTOM	PROBABLE CAUSE	REMEDY
HIGH GAS PRESSURE	Incorrectly adjusted gas regulator.	Readjust.
	Incorrect spring or orifice in gas regulator.	Replace spring or orifice.
	Excessive line pressure.	Reduce line pressure.

REPAIR & REPLACEMENT

CRANKCASE

The VR220/330 crankcase is a singe piece iron casting. There are five main bearing supports for the 4 cylinder engine and seven main bearing supports for the 6 cylinder engine. There are also locations for four or six wet-type cylinder sleeves. There are cooling water passages between the side walls of the crankcase casting and the cylinder sleeves. Thus, the sleeves are always in direct contact with the coolant. The cylinder sleeves are removable, so it is necessary to maintain a seal at the upper and lower sleeve-to-crankcase contact surfaces. This is done at the top of the sleeve by the head gasket which seals the mating surfaces of the sleeve flange and the crankcase deck. The bottom seal is made with three rubber seal rings at the lower end of the sleeve.

The crankcase has three (VR220) or four (VR330) support locations for the camshaft journals. These support the camshaft at the front and rear and at one or two intermediate points. All camshaft supports have pressed-in bushings.

VR220/330 engines equipped with the optional hydraulic pump drive have an additional bearing pressed in the gear cover, in front of the cam gear.

At the rear end of the crankcase is a mounting surface for a flywheel housing and a retainer for the crankshaft lip-type oil seal. To ensure accurate mounting of the clutch or other drive unit in the flywheel housing, this rear mounting surface is held to very close tolerances. Whenever the power take-off, flywheel, or flywheel housing is removed, the runouts for the flywheel face, flywheel housing face, flywheel housing bore, and pilot bearing bore should be checked and adjusted as required. (See Installation section.) The rear oil seal should be installed between flush with and .060" (1.52 mm) below the back surface of the oil retainer. The oil seal lip faces towards the crankcase.

Faced mounting bosses and connections are provided on the crankcase exterior for mounting accessories, lines, and other equipment. Crankcase ventilation is accomplished by a breather tube located in the valve cover.

Cylinder Heads And Valves

The cast iron cylinder head is designed and fabricated especially for the temperatures and pressures of industrial use.

The poppet-type intake and exhaust valves on the VR Series engines have hardened tips and recesses for split-taper locks.

All VR Series engines intake and exhaust valves use a valve stem sea., consisting of a polyacrylic jacket and two steel retaining rings.

If the head has not been removed and the valve seals are to be replaced, care must be taken so the valves don't fall into the cylinder when the valve tapers are removed.

To secure the valves, remove spark plug. Fit an air hose adapter to the spark plug hole, and fill the cylinder with compressed air. The cylinder must be kept pressurized at all times. The air pressure will be enough to keep the valves in the closed position.

To install these seals, proceed as follows:

1. Make sure the valve and guide assemblies are clean.
2. Gently slide the seal over the valve stem, and down until it comes into contract with the valve guide. The end of the seal with the widest opening must be over the guide.
3. Press the seal into place. All downward pressure should be exerted on the lower retaining ring, not on the polyacrylic part of the seal.

Never re-use valve stem seals. Always replace with new seals whenever a valve, valve guide or valve stem seal is removed.

The exhaust valves of all VR Series engines and both valves on Turbocharged gas engines seat on hardened valve seat inserts in the cylinder heads. These insets are shrunk and pressed into place. Intake and exhaust guides are pressed into place in the cylinder heads, but may be replaced.

Valves and springs are held in position by hardened retainers, which are stepped to center the springs. The retainers are seated on split-taper locks.

Valve actuation is obtained through chilled and polished mushroom-type valve lifters, riding directly on the camshaft lobes. This motion is transmitted to the rocker arms by tubular steel push rods, equipped with a hardened socket at the top end and a hardened tip at the bottom. There is a socket in the valve lifter to receive the lower end push rod tip.

The ductile iron rocker arms pivot on a hardened, hollow steel shaft. The rocker arms are curved to align with their respective intake or exhaust valve tips. To ensure long wear and accurate adjustment, the rocker arms are hardened in the valve-rocker arm contact area. Drilled openings along the shaft mate with passages in the rocker arms to permit lubrication of the entire overhead mechanism.

Cylinder Sleeves

The wet-type cylinder sleeves are iron centrifugal castings, designed for long wearing qualities and resistance to distortion. Each sleeve has a shoulder and flange at the upper end to locate the sleeve in crankcase and prevent shifting and leakage when the cylinder head and gasket are torqued into position. This flange, and the crankcase deck recess into which it fits, both have precision-finished mating surfaces to form a water seal. The cylinder sleeve projects above the deck to ensure a tight crush gasket joint. Whenever sleeves are installed, sleeve projection should be checked. The lower end of the sleeve projection should be checked. The lower end of the sleeve is tapered, with grooves immediately above the taper for the rubber sealing rings. The top two grooves contain a black rubber sealing ring and the bottom groove a red silicone sealing ring.

Cylinder Sleeve Projection

The following procedure should be used to measure cylinder sleeve projection:

1. After removal of the head, clean carbon and other deposits from the face of the block and sleeve projections.
2. Place a metal bar across the center of the sleeve and bolt both ends into place using 150 ft. lbs. (203.4 N-m) torque. This step will force the sleeve into the position it normally occupies when the head is in place.
3. Use a dial indicator to measure the height of the sleeve projection above the face of the block.

Pistons

The aluminum alloy pistons are heavy-duty castings. The piston pins are full floating, and are held in the piston by two spring-type clips. Two compression and one oil control ring are used on all pistons.

CAUTION

Pistons for all VR220/330 Series engines are marked with the word FRONT and an arrow, and must be installed with the arrow pointing towards the gear cover (front) end of the engine.

Connecting Rods

I-section connecting rods are used in the VR Series. The rods and caps are forged. Hard bronze bushings are a press fit in the piston-pin end and are diamond bored for precise alignment. Piston pin bushings should be installed between flush with and .010" (.25 mm) below the side of the rod. Press each bushing in so that the relief notch on the side of the bushing surrounds, but does not cover, the oil hole in the connecting rod. Connecting rods are never bent for alignment purposes, neither at the factory nor in the field. Two heat-treated connecting rod screws hold the bearing caps in place. The upper and lower halves of connecting rod bearings are interchangeable.

CAUTION

The connecting rodcap must be aligned to the blade during rod installation. Improper rod alignment will decrease side play and lead to rapid rod and crankshaft wear.

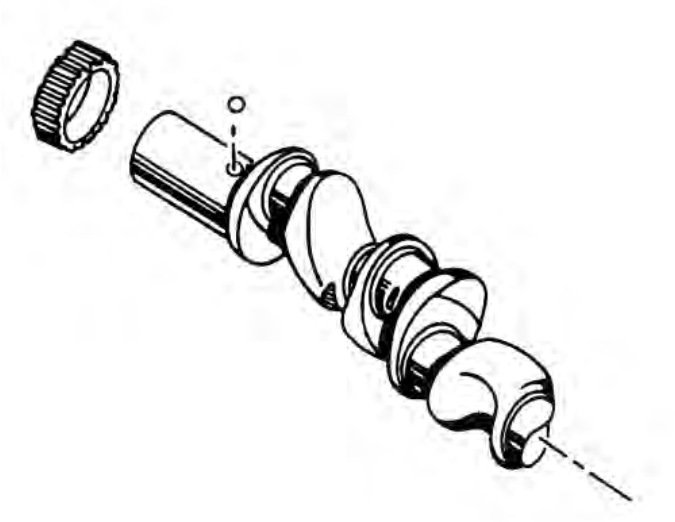
To align the blade and cap, hold the cap in position against the rod blade and snug the bolts into position. Do not tighten the bolts. Then, with a soft hammer, alternately tap the rod blade and then the rod cap to either side of the crank, against one of the crank thrust areas. When both the rod blade and cap are against the same thrust area, the cap and blade will be in alignment, and the connecting rod bolts can be torqued.

Crankshaft

The crankshaft is precision ground from a heat-treated steel forging. The crankshaft has flame-hardened main bearing journals which run in steel backed, alloy bearing shells. Connecting rod bearings are of similar construction for maximum serviceability.

CAUTION

The main bearing shells are stamped "upper" and "lower" and are not interchangeable. The main bearing upper shells are grooved while the lower are not.



The rear extremity of the shaft has an integral mounting flange for the flywheel. This flange is drilled and tapped for six flywheel mounting bolts. One bolt hole is offset 1/16 inch (1.6 mm) in order to ensure proper flywheel installation. The front extension of the crankshaft provides the mounting surface to support the press fitted crankshaft drive gear. The crankshaft pulley is retained by six crank bolts. Two of the six bolt holes in the front of the crankshaft are slightly offset to allow for proper crankshaft pulley installation. VR330 Series engines operating over 2200 rpm are also equipped with a rubber bonded type vibration damper.

The VR Series crankshafts use a chrome alloy steel ball to retain the gear. This ball protrudes from a hole drilled into the nose of the crankshaft. During servicing, take care not to lose the ball if removing the crankgear. The gear can be reinstalled by resting the ball in the drilled hole, and pressing the heated gear into place.

Flywheel

To prevent oil leaks from the flywheel mounting flange always install the flywheel bolts using type C or CV Loctite. Torque to 65 ft. lbs. (88 N-m).

Camshaft

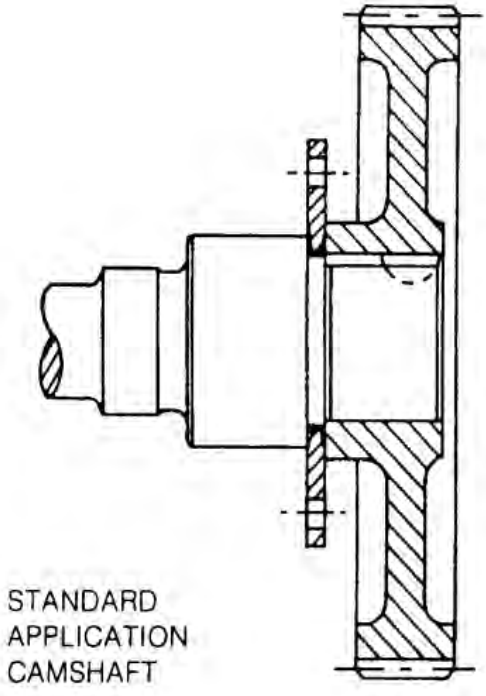
The camshaft is a single casting, with ground cam lobes and journals. Individual hardened cam lobes actuate each of the valve lifters. An integral worm gear drive drives the internal oil pump. The forward end of the camshaft is keyed to hold the camshaft drive gear. Lubricating oil is supplied to each of the three or four journal areas. A steel-backed babbitt bushing, pressed in the main crankcase, supports the camshaft at all three or four journals.

For certain applications, the forward end of the camshaft is designed to be supported in an outboard bearing pressed into the front gear cover. These special
application camshafts have oil drillings to feed oil to this outboard bearing.

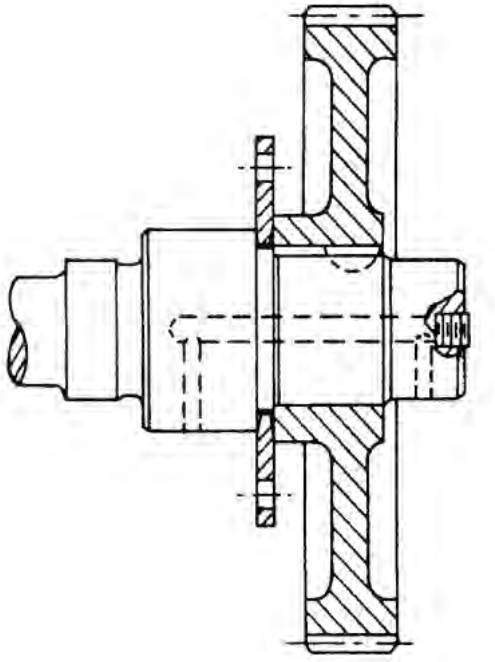
CAUTION

The front end of the special application camshaft must be plugged to prevent loss of oil pressure.

If it is necessary to replace the camshaft outboard bushing in the gear cover, it should be installed approximately .125” (3.17 mm) below the counterbore.



STANDARD
APPLICATION
CAMSHAFT



SPECIAL APPLICATION CAMSHAFT

Installation Of New Valve Lifters Along With New Camshaft

When a new camshaft is installed to replace a failed or worn camshaft, an entire set of new valve filters must also be installed. The new camshaft will not be covered by warranty unless new lifters are also installed.

CAUTION

Wear patterns on the old lifters and/or damaged old lifters can result in early failure of the new camshaft when new lifters are not installed.

Protection Of Engine And Parts

During repair and replacement procedures, care should be exercised to prevent damaging parts in handling. All machined surfaces should be protected and kept separate from other parts. Parts that are easily damaged require particular care to prevent bending, denting, or breakage. All parts should be covered to protect them from dirt. This will also speed re-assembly by reducing cleanup time at assembly.

When parts are removed, the resulting openings into the engine should be covered to keep dirt or other foreign matter from entering the engine.

Cleaning And Inspection Of Engine Parts

Parts and assemblies can frequently be inspected without removal or complete disassembly.
Judgement should be exercised to avoid disassembly beyond what is necessary to correct the fault and put the part or assembly in serviceable condition.

The following paragraphs describe cleaning procedures and, where applicable, name cleaning materials to be used if available. The different metals used in the engine components require different techniques and cleaning materials, so a generalization of cleaning methods cannot readily be supplied.

Carbon Removal

Carbon must be removed during maintenance operations from valves, pistons, and cylinder heads.

Carbon can be removed from hardened surfaces by first softening the carbon.

Soften the carbon by soaking the parts in a carbon removing compound. Rinse in kerosene or hot water and remove softened carbon with a rag or soft brush.

CAUTION

Never scrape parts with a metallic scraper.

Castings

Use a cleaning solvent to clean inner and outer surfaces of castings and all areas exposed to oil and grease.

Remove sludge and gum deposits with a stiff brush.

After cleaning, blow out all tapped holes and dry castings thoroughly with compressed air.

Oil Passages

Clean oil passages with wire brushes or probes to break up any sludge or gum deposits.

Wash passages by flushing with cleaning solvent and dry thoroughly with compressed air.

CAUTION

When cleaning lube oil passages, do not use any material that will leave lint or other foreign particles in the oil passages. Clogging or interference in passages may be caused by any foreign material. Such material could be worked into the bearings upon operating the engine, or could block oil flow to the engine components.

Oil Seals And Hoses

Clean seals and hoses with soap and water. Do not allow cleaning solvent to contact seals and hoses.

Ball And Roller Bearings

CAUTION

Do not spin bearings with air

Anti-friction bearings should receive special handling. As soon as a bearing is removed, cover it to keep out dirt and abrasives. Wash bearings in kerosene and inspect races and balls or rollers. Discard bearings if they are pitted, scored, or burned. If a bearing is serviceable, coat it with light oil and wrap it in clean paper. Do not unwrap bearings until just before installation.

Always use the proper tool or fixture for pulling or pressing out bearings. Normally, bearings should not be removed unless replacement is required.

When installing a bearing against the shoulder on a shaft,

be sure the chamfered side is toward the shaft shoulder. When a bearing is to be pressed in, lubricate the mating surfaces prior to assembly. When a bearing is to be pressed into a bore, always exert the press forces onto the outer race of the bearing only. When pressing a bearing onto a shaft, exert the press force on the inner race. This will avoid bearing distortion.

Oil Seals

Oil seals should not be removed unless absolutely necessary for gaining access to another item, or unless they are being replaced due to damage or wear. If the seal must be cut through to remove it, care must be taken not to damage the seating area around it.

Lubricant leakage around the shaft or bearing is usually a sign of oil seal failure.

Oil seals that leak, or are worn to a point where they may begin to leak, must be replaced. An oil leak that is corrected in time will prevent overheated bearings resulting from a loss of lubricant. Never use oil seals a second time; once removed, they must be discarded and replaced.

A lubricant must be applied to the lip of all shaft-type rubber seals before installation. This will prevent seal damage during initial running, until oil has contacted the sealing face.

Attaching Parts

Use screws of a correct length. A screw which is too long may “bottom” before the head is tight against the part it is to hold. In addition, the threads may be damaged when the screw is tightened. If a screw is too short, there will not be enough thread contact to hold the part securely.

In addition to size variations, attaching parts may vary in material and heat treatment. Do not mix different types of attaching parts.

Lock washers, cotter pins, or other locks should be used to lock each nut and cap screw when specified.

Gears

Always use the tools recommended (or equivalent) for gear removal and installation. Gears must be carefully inspected for damaged or worn teeth. Always align the keyway in the gear with the keyway in the shaft before installation. Lubricate the mating surfaces of the gear and shaft when pressing the gear onto the shaft.

If crankshaft gear removal is necessary, use an appropriate heavy-duty puller. Never heat the gear for removal, since this may damage the crankshaft. Before installing new crankshaft gear, heat the gear in an oven or other even source of heat to a maximum of 400°F. (205°C.) to facilitate installation. Do not use a torch to heat the gear. The gear will not heat and expand evenly when torch heated.

WARNING

Use insulated gloves when handling a hot gear.

Quickly place the heated gear onto the crankshaft and hold it securely in place until it cools and contracts. The gear may be carefully tapped into place with a soft face hammer or driving tool if it sticks due to slight cocking or binding.

If the idler gear bushing is replaced, it should be installed approximately .125” (3.17 mm) below the front of the gear hub.

Gaskets

Install gaskets where required and use new ones whenever possible. Never use cork or felt gaskets a second time.

CAUTION

Be sure the holes in the gaskets correspond with lubricant passages in mating parts. If it is necessary to fabricate gaskets, select stock of a proper type and thickness, and be sure to cut the holes in the right places. Blank or incorrectly installed gaskets can cause serious damage by blocking lubricant passages.

Bushings

Do not remove bushings unless inspection reveals damage or wear that exceeds the specified clearance, or unless the bushing is loose in its mating bore. Bushings should be pressed out whenever possible. When pressing or driving (in or out), apply pressure directly in line with the bore. If the bushing must be driven, use a driver of the largest possible diameter or a bar with a smooth, flat end. Never drive bushings with a hammer. If the bushing has an oil hole, be sure to line up the oil hole in the bushing with the oil hole in the part in which it is assembled.

NOTE: *Service cam bushings should be installed when cam bushings need replacing. Service cam bushings are manufactured with dimensions to allow for proper bearing clearance and alignment without line reaming.*

Shafts

If a shaft offers unexpected resistance to removal, check carefully to see that all nuts, keys and cap screws have been removed before using force. Also check for interference with another part which must be removed first. Clean the rust preventive compound from all machined surfaces of all new parts before installing. Shafts fitted to other parts with tapers are always very tight. If they are not tight when disassembled, inspect tapers and discard the part if the taper is worn. Before assembling shafts with tapers, be sure tapers are clean, dry and free from burrs. Press mating parts together tightly.

Flexible Hose Lines

Fittings should be installed by threading the swivel nuts on by hand until they are finger tight. Hold the socket on the hose with one wrench and tighten the swivel nut securely with another wrench. This method prevents twisting the hose and does not exert any strain on the hose. Correct installation prevents hose damage that would not appear until there is pressure on the hose.

Repairing Damaged Threads

Damaged threads should be repaired by use of thread restorer or by chasing in a lathe. Internal threads should be repaired using a tap of a correct size.

If threads cannot be satisfactorily repaired, install a Heli-Coil or other standard insert or replace the part.

Repair Of Damaged Machined And Polished Surfaces

Smooth rough spots, scores, burrs, galling, and gouges from damaged machined and polished surfaces so that the part will efficiently perform its normal function. The finish of the repaired part is to approximate that of the original finish. In performing any of these operations, critical dimensions must not be altered.

Removal Of Rust Or Corrosion

Remove corrosion from all parts of the material. To remove rust or corrosion, use a brass wire brush, abrasive cloth, bead blast, vapor blast equipment, or rust remover except on highly polished surfaces. On these surfaces, buffing or use of crocus cloth is recommended.

CAUTION

Do not expand rings more than is necessary to slip over the piston. Over-expansion of rings causes stress and may lead to early failure. Ring gaps should be staggered 180° to prevent blowby during initial starting. Rings must be thoroughly lubricated with engine oil before being installed in the cylinder sleeve.

Two oil ring rails are separated by an oil ring rail spacer. The ends of the spacer are butted against each other with the upper and lower rail gaps staggered 120° and 140° respectively from the spacer gap.

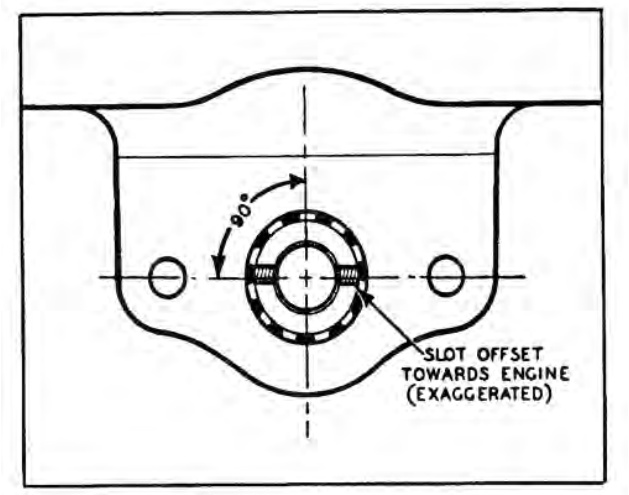
Compression rings of VR Series engines which are notched on the inner edge must be installed with the notch toward the top of the piston. Compression rings of VR Series engines which are notched on the outer edge must be installed with the notch toward the bottom of the piston. The rings are stamped “TOP” or include a center punch mark which must be installed toward the top of the piston.

CAUTION

All VR Series engine pistons are marked with an arrow and the word FRONT, and the piston must be installed with the arrow pointing toward the front of the engine.

Oil Pump Installation

When the oil pump of VR Series gas or gasoline engines is removed, it must be re-installed so the ignition drive keyway is positioned as illustrated, with the number one piston on the compression stroke and the timing mark aligned.



DISTRIBUTOR DRIVE KEYWAY

Water Pump Seal Installation

When installing a new water pump seal, carefully wipe the carbon sealing surface and the mating ceramic surface with a soft cloth or absorbent paper to remove all traces

of wax, grease, or oil. Use a small amount of the seal, apply either a 1% soluble oil and water solution or ethylene glycol type antifreeze to both sealing faces.

Water Pump Or Fan Pulley Installation

Before replacing the water pump or fan pulleys, carefully check all joining surfaces. These pulleys are held on by an interference fit. Loctite 601 bearing mount should always be used to secure the pulley.

Vibration Damper Replacement

The vibration dampers used on current VR330 engines have radially aligned center punches on the inner and outer members. When the angular displacement between these marks equals or exceeds 0.10 inch (2.5 mm), the damper has exceeded its useful life and should be replaced.

To replace the rubber bonded vibration damper, use the following procedure:

1. Remove the six screws securing the vibration damper to the crankshaft pulley.2. Remove damper.

3. Install a new vibration damper on the pulley and tighten the screws to 27-29 ft. lbs. (37-39 N-m).

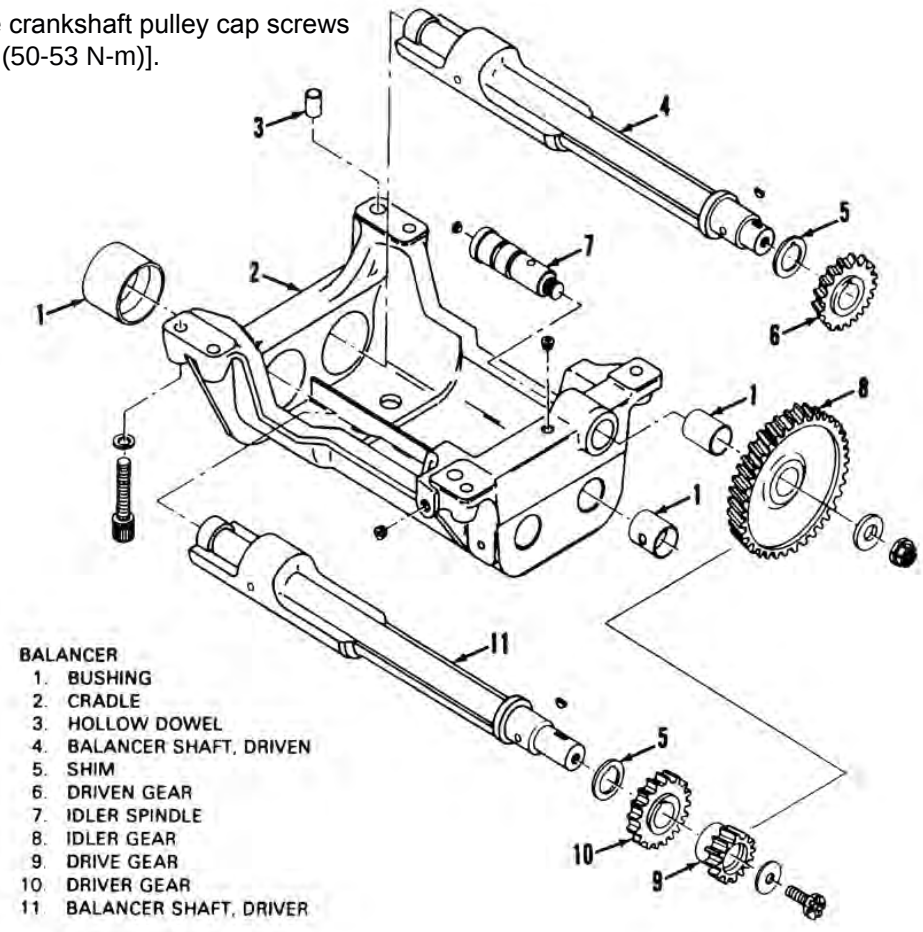
4. Check the torque on the crankshaft pulley cap screws [should be 37-39 ft. lbs. (50-53 N-m)].

Secondary Balancer

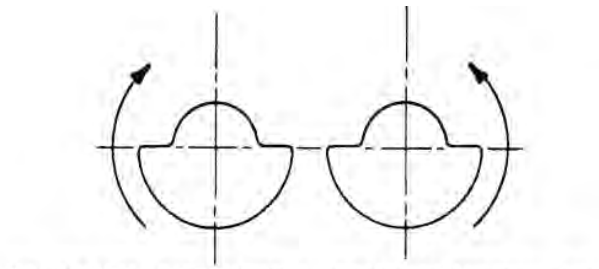
The VR220 Series engines can be equipped with a balancer to counteract secondary inertial forces within the engine. The balancer is a force generator, designed to create a counteracting force at the right time to reduce this secondary force harmonic. (Primary, or rotating, forces are inherently balanced due to the crankshaft throw arrangement.)
The balancer shafts rotate at twice engine speed, and in opposite directions to one another. As the balancer shaft eccentrics rotate up or down together, the centrifugal forces of the eccentrics combine to counteract the reciprocating forces from the pistons and connecting rods. As the eccentrics rotate apart or towards each other, the forces cancel themselves out, thereby creating no lateral forces.

A Secondary balancer is not required on 6 cylinder engines, due to the arrangement of the crank throws. All primary and secondary forces are inherently balanced in the 6 cylinder VR330 series engines.

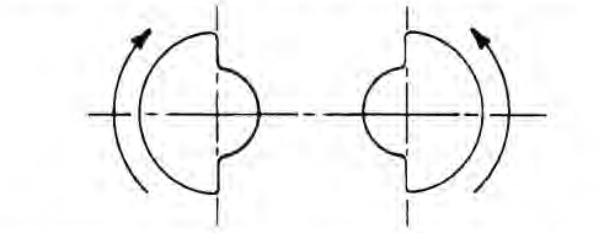
Balancer maintenance is minimal. The system is pressure lubricated through crankcase passageways. The balancer retainers must be torqued to 40-44 ft. lbs. (54-59 N-m) (dry) maximum. Balancer torques and backlashes are listed in the Fits and Clearances section.



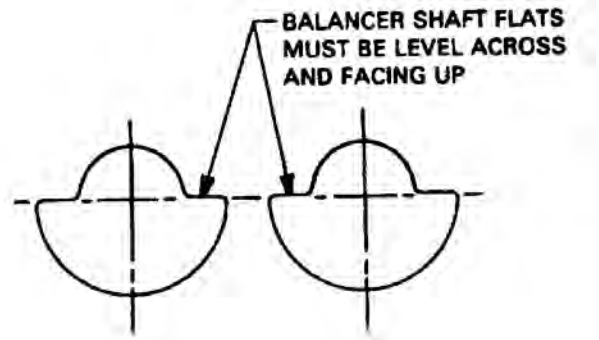
BALANCER
1. BUSHING
2. CRADLE
3. HOLLOW DOWEL
4. BALANCER SHAFT, DRIVEN
5. SHIM
6. DRIVEN GEAR
7. IDLER SPINDLE
8. IDLER GEAR
9. DRIVE GEAR
10. DRIVER GEAR
11. BALANCER SHAFT, DRIVER



BALANCER ECCENTRICS SYNCHRONIZING TO COMBINE FORCES IN THE VERTICAL DIRECTION.



BALANCER ECCENTRICS ROTATING APART TO CANCEL LATERAL FORCES.



CAUTION

Crankcases A216020 and C216020 use 28474A retainer. Crankcase A216020A uses 28669 retainer.

Balancer timing can be accomplished with the gear cover removed and the flywheel set at 0° TDC (compression or exhaust stroke), simply line up timing marks G-G and P-P stamped on the balancer idler gear, driver gear, and driven gear. Next, install the balancer assembly to the engine while lining up timing marks B-B stamped on the balancer idler gear and crankshaft gear. Recheck to see that the flywheel is still at 0° TDC and the balancer timing marks all line up.

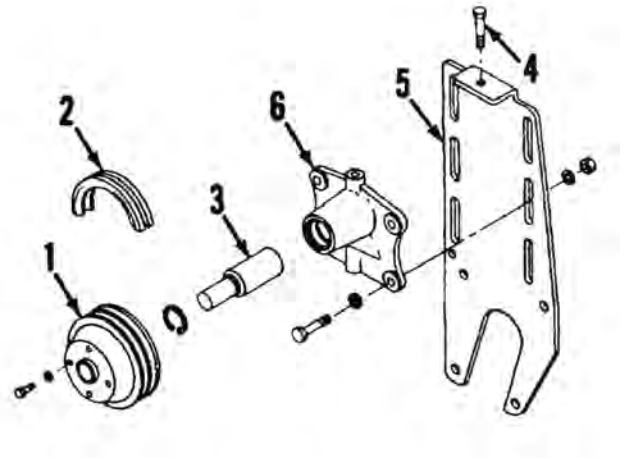
If the gear cover is not removed from the engine, timing marks B-B are difficult to see. If you cannot see the timing marks, use the following to time the balancer to the engine: The flywheel should again be set at 0° TDC. Line up timing marks G-G and P-P on the balancer gears. Visually check the balancer shafts to make sure the flats are level across and in the up position as shown in the illustration below. Next, install the balancer assembly to the engine, being careful not to turn the balancer gears or the crankshaft. After the balancer is attached to the engine, check again to see that the flywheel is at 0° TDC and the balancer shafts have the flats level across and facing up and the balancer is correctly timed to the engine.

NOTE: *After timing marks G-G, P-P, and B-B are lined up, it could take as many as nineteen revolutions of the crankshaft before they all line up again. If the balancer is suspected of being out of time, rotate the crankshaft until the timing marks line up. If the timing marks will not line up within nineteen revolutions, the balancer is incorrectly timed.*

Always be sure to seal the gasket before installing. Mount the pump firmly to avoid oil leaks from the gear cover.

Fan Height Adjustment And Fan Belt Tightening Procedures

The fan height on the VR220/330 can be adjusted to 16, 18, 19 or 21 inches above the crankshaft center line by moving the fan mounting pulley and/or inverting the pulley mounting bracket.



FAN BRACKET
1. PULLEY
2. FAN BELTS
3. SHAFT
4. FAN HEIGHT ADJUSTING SCREW
5. BRACKET SUPPORT
6. REVERSIBLE PULLEY MOUNTING BRACKET

The following table lists the different belts and adjusting screws needed to change fan heights:

Nominal Fan Height	Fan Belts		Fan Adjusting Screw	
	Part Number	Length	Part Number	Screw Size
16" (41 cm)	A216003C	47" (119 cm)	26762	3/8"-16 x 5 1/4"
18" (46 cm)	A216003	51" (130 cm)	21374	3/8"-16 x 4 1/4"
19" (48 cm)	A216003A	53" (135 cm)	21362	3/8"-16 x 2"
21" (53 cm)	A216003B	57" (145 cm)	21354	3/8"-16 x 1-3/8"

Tighten all belts to ¼" (6 mm) deflection.

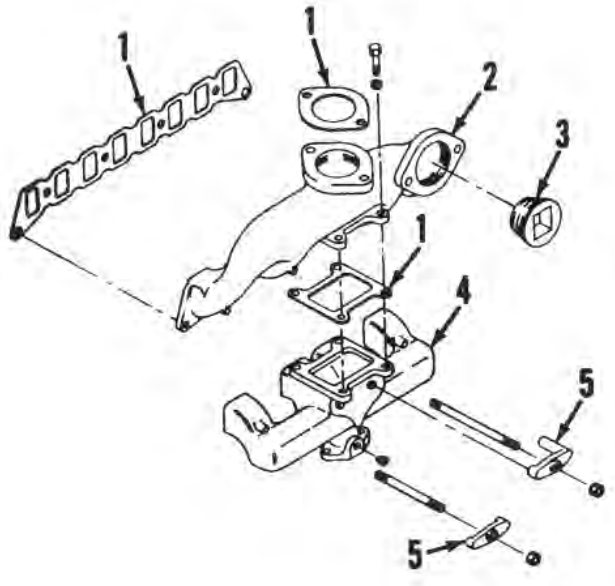
The fan belts are tightened by loosening the pulley mounting bracket bolts and turning the adjusting screw until the belts reach the proper tension. Tighten the bolts that secure the pulley mounting bracket to the bracket support.

Alternator-Water Pump Belt Tightening

To tighten the alternator-water pump belt, loosen the mounting and adjusting strap bolts and pivot the alternator (or belt tightener) away from the engine until the belt reaches the desired tension. Tighten the adjusting strap bolt and then the mounting bolt.

COMBINATION MANIFOLD

The combination intake/exhaust manifold on the VRG220 can be modified to either a top exhaust or side exhaust outlet to fit the application. The outlet is switched by moving the 2-½" pipe plug to whichever outlet is to be sealed off.



COMBINATION MANIFOLD
1. GASKET
2. EXHAUST MANIFOLD
3. PLUG
4. INTAKE MANIFOLD
5. MANIFOLD CLAMPS

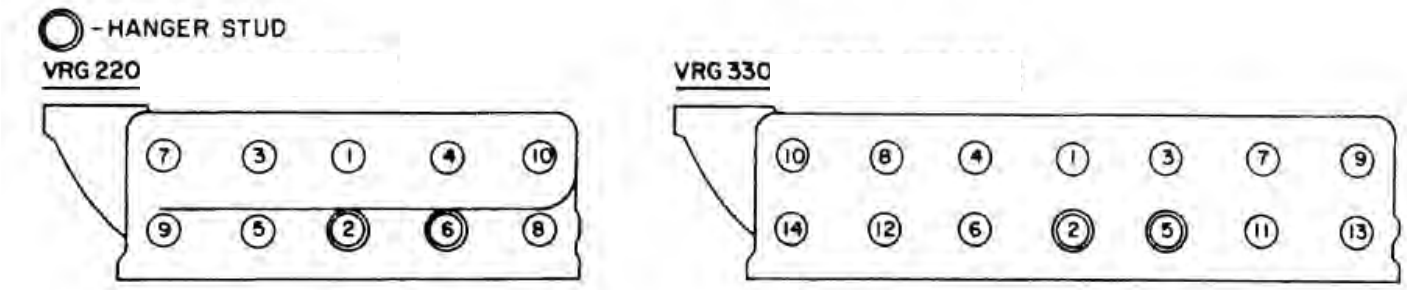
TORQUE RECOMMENDATIONS

The values specified below are to be used only in the absence of specified torquing instructions and are not to be construed as authority to change existing torque values. A tolerance of + 3% is permissible on these values, which are for oiled threads. Reduce torque by 20% if new plated capscrews are used.

HEAT TREATED MATERIAL SAE GRADE 5 & GRADE 8

NOTE: INCREASE VALUES 1/3 FOR DRY THREADS

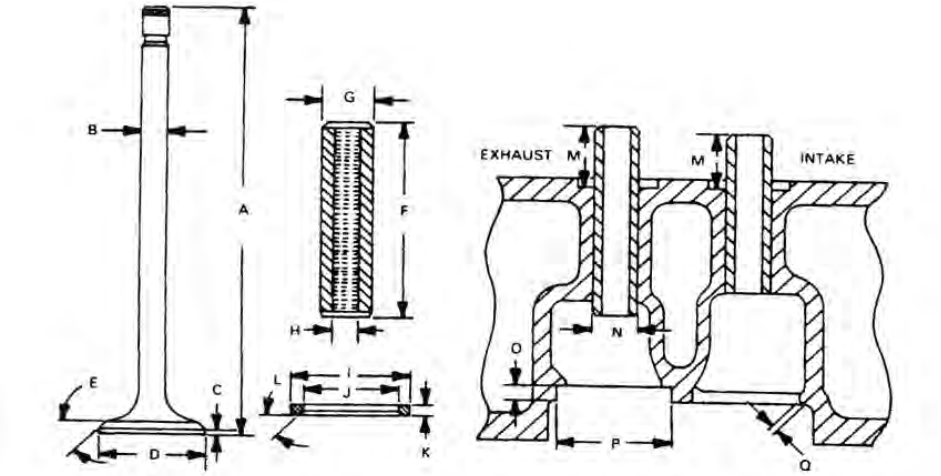
Thread Size	Grade 5 (3 radial dashes on bolt or cap screw head)		Grade 8 (6 radial dashes on bolt or cap screw head)	
	Pounds-Feet	N-m	Pounds-Feet	N-m
1/4-20	6	8.13	9	12.2
1/4-28	7	9.5	11	14.91
5/16-18	13	17.6	18	24.4
5/16-24	15	20.34	21	28.47
3/8-16	24	32.54	34	46.09
3/8-24	27	36.61	38	51.52
7/16-14	38	51.5	54	73.21
7/16-20	42	56.9	60	81.35
1/2-13	58	78.6	82	111.17
1/2-20	65	88.1	90	122.02
9/16-12	84	113.9	120	162.69
9/16-18	93	126.1	132	178.96
5/8-11	115	155.9	165	223.7
5/8-18	130	178.3	185	250.82
3/4-10	205	277.9	290	393.18
3/4-16	230	311.8	320	433.86
7/8-9	305	413.5	455	616.89
7/8-14	335	454.2	515	698.24
1-8	455	616.9	695	942.28
1-14	510	691.5	785	1064.30
1-1/8-7	610	827	990	1342.24
1-1/8-12	685	928.7	1110	1504.91
1-1/4-7	860	1166	1400	1898.12
1-1/4-12	955	1294.8	1550	2101.49
1-3/8-6	1130	1532.05	1830	2481.11
1-3/8-12	1290	1748.98	2085	2826.84
1-1/2-6	1500	2033.7	2430	3294.59
1-1/2-12	1690	2291.3	2730	3701.33
1-3/4-5	2370	3213.25	3810	5165.59
2-4-1/2	3550	4813.09	5760	7809.41



CYLINDER HEAD TORQUING SEQUENCE

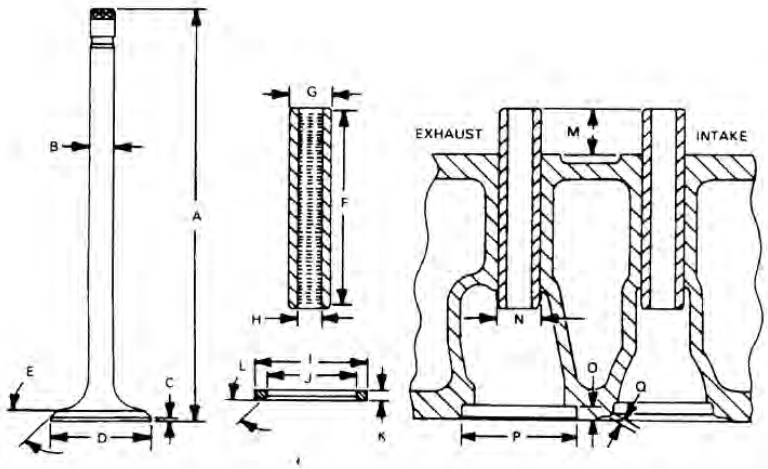
TORQUES - GAS ALL VRG220/330		
	FTLBs	**Nm**
Cylinder Head Cap Screws	205 - 215	277 - 291
Main Bearings	130 - 135	176 - 183
Flywheel	65 - 69	88 - 94
Connecting Rods	44 - 46	60 - 62
Crank Pulley Screws	37 - 39	50 - 53
Spark Plugs	20 - 23	27 - 31
Vibration Damper	27 - 29	37 - 39
Balancer to Crankcase	40 - 44 Dry	54 - 59
Balancer Idler Gear Nut	31 - 35	42 - 47
Balancer Shaft Gear Screws	31 - 35 Dry	42 - 47
Alternator Pulley Nut	40 - 60	54 - 81
Alternator Battery Terminal Nut	2 - 3	2.7 - 4
Rocker Arm Cover	8	11
Rear Oil Seal Screw	13	18

CLEARANCES & TOLERANCES



VALVE TRAIN, VALVE PORT CLEARANCES
excluding Turbocharged & Crossflow

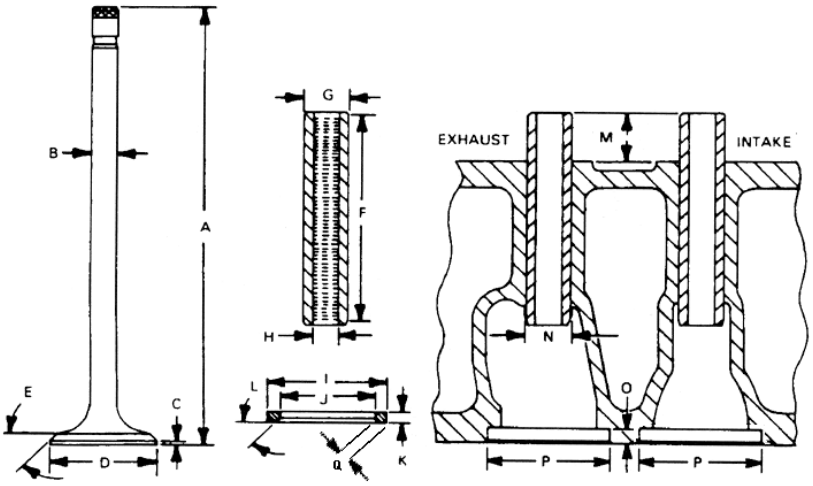
		Inches	mm
Valve Length	Intake and Exhaust	5.3935 - 5.4185	136.99 - 137.63
Valve Stem Diameter	Intake Exhaust	.372 - .373 .371 - .372	9.45 - 9.47 9.42 - 9.45
Valve Lip Thickness	Intake and Exhaust	.053 - .073	1.35 - 1.85
Valve Face & Seat Runout (Maximum)		.002	.05
Valve Head Diameter	Intake Exhaust	1.615 - 1.63 1.508 - 1.518	41.02 - 41.53 38.30 - 38.56
Valve Face Angle	Intake and Exhaust	44° 30’ + 15’	
Guide Length	Intake Exhaust	2.396 - 2.41 2.62 - 2.64	60.86 - 61.37 66.6 - 67.1
Guide OD	Intake and Exhaust	.6255 - .626	15.888 - 15.900
Guide ID	Intake and Exhaust	.374 - .375	9.50 - 9.53
Guide to Stem Clearance	Intake Exhaust	.001 - .003 .002 - .004	.03 - .08 .05 - .10
Exhaust Seat Insert OD		1.6270 - 1.6275	41.326 - 41.339
Exhaust Seat Insert ID		1.385 - 1.390	35.18 - 35.31
Exhaust Seat Insert Depth		.207 - .209	5.26 - 5.31
Intake Seat Angle and Exhaust Seat Insert Angle		45° - 45° 30’	
Guide Extend Above Head	Intake Exhaust	.834 - .854 .928 - .948	21.18 - 21.69 23.57 - 24.08
Guide Bore in Head		.6245 - .6250	15.862 -15.875
Exhaust Seat Insert Counterbore Depth		.217 - .220	5.51 - 5.59
Exhaust Seat Insert Counterbore Diameter		1.624 - 1.625	41.25 - 41.28
Intake Seat Width		.060 - .083	1.52 - 2.11
Exhaust Seat Insert Width		.074 - .102	1.88 - 2.59
Spring Free Length	Intake Exhaust	2-9/16 + 1/16 2-9/16 + 1/16	65.07 + 1.59 65.07 + 1.59
Valve Closed Spring Length	Intake Exhaust	1-29/32 @ 59 + 4# 1-29/32 @ 59 + 4#	48.45 @ 27 + 1.8 kg 48.45 @ 27 + 1.8 kg
Valve Open Spring Length	Intake Exhaust	1-1/2 @ 95 + 4# 1-1/2 @ 95 + 4#	38.25 @ 43 + 1.8 kg 38.25 @ 43 + 1.8 kg



VALVE TRAIN, VALVE PORT CLEARANCES

Crossflow

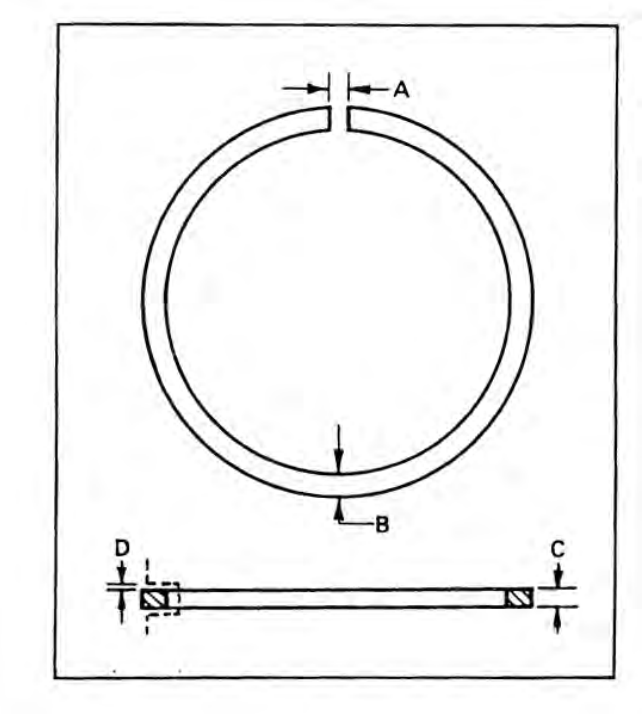
		Inches	mm
Valve Length	Intake and Exhaust Exhaust	6.400 - 6.425 6.414 - 6.439	162.56 - 163.20 162.92 - 163.55
Valve Stem Diameter	Intake Exhaust	.3718 - .3725 .3713 - .3720	9.444 - 9.462 9.431 - 9.449
Valve Lip Thickness	Intake and Exhaust Exhaust	.043 - .063 .057 - .077	1.09 - 1.60 1.45 - 1.96
Valve Face & Seat Runout (Maximum)		.002	.05
Valve Head Diameter	Intake Exhaust	1.714 - 1.724 1.495 - 1.505	43.54 - 43.79 37.97 - 38.23
Valve Face Angle	Intake Exhaust	29° 30’ + 15’ 44° 30’ + 15’	
Guide Length	Intake and Exhaust	3.115 - 3.135	79.12 - 79.63
Guide OD	Intake and Exhaust	.6255 - .6260	15.888 - 15.900
Guide ID	Intake and Exhaust	.373 - .374	9.47 - 9.50
Guide to Stem Clearance	Intake Exhaust	.0005 - .0022 .0010 - .0027	.013 - .056 .025 - .069
Exhaust Seat Insert OD		1.6270 - 1.6275	41.326 - 41.339
Exhaust Seat Insert ID		1.312 - 1.313	33.32 - 33.351
Exhaust Seat Insert Depth		.207 - .209	5.26 - 5.31
Intake Seat Angle		30° - 30° 30’	
Exhaust Seat Insert Angle		45° - 45° 30’	
Guide Extend Above Head	Intake and Exhaust	.740 - .760	18.80 - 19.30
Guide Bore in Head		.6245 - .6250	15.862 -15.875
Valve Extension Above Head Deck (Must be checked after installing valve seat inserts or resurfacing head.)		.014 - .029	.36 - .74
Exhaust Seat Insert Counterbore Depth		.217 - .220	5.51 - 5.59
Exhaust Seat Insert Counterbore Diameter		1.624 - 1.625	41.25 - 41.28
Intake Seat Width		.060 - .083	1.52 - 2.11
Exhaust Seat Insert Width		.074 - .102	1.88 - 2.59
Spring Free Length	Intake Exhaust	2-9/16 + 1/16 2-9/16 + 1/16	65.07 + 1.59 65.07 + 1.59
Valve Closed Spring Length	Intake Exhaust	1-29/32 @ 59 + 4# 1-29/32 @ 59 + 4#	48.45 @ 27 + 1.8 kg 48.45 @ 27 + 1.8 kg
Valve Open Spring Length	Intake Exhaust	1-1/2 @ 95 + 4# 1-1/2 @ 95 + 4#	38.25 @ 43 + 1.8 kg 38.25 @ 43 + 1.8 kg



VALVE TRAIN, VALVE PORT CLEARANCES

Turbocharged

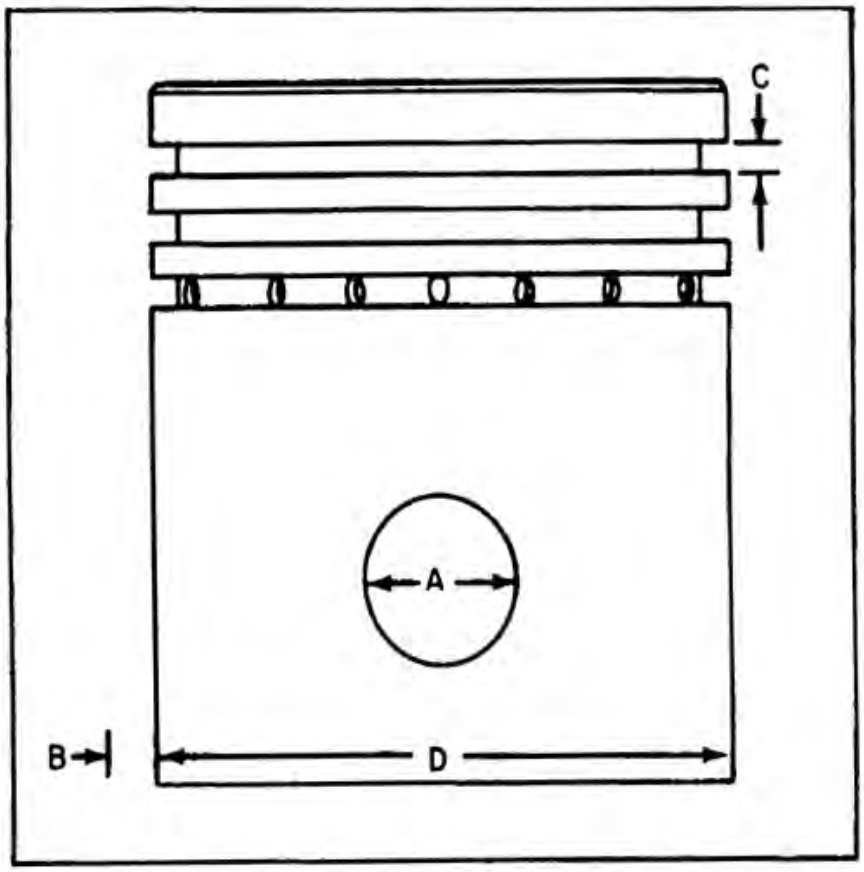
		Inches	mm
Valve Length	Intake and Exhaust	5.3935 - 5.4185	136.99 - 137.63
Valve Stem Diameter	Intake Exhaust	.372 - .370 .371 - .372	9.45 - 9.47 9.42 - 9.45
Valve Lip Thickness	Intake and Exhaust	.053 - .073	1.35 - 1.85
Valve Face & Seat Runout (Maximum)		.002	.05
Valve Head Diameter	Intake Exhaust	1.615 - 1.63 1.508 - 1.518	41.02 - 41.53 38.30 - 38.56
Valve Face Angle	Intake and Exhaust	44º 30’ + 15’	
Guide Length	Intake Exhaust	2.396 - 2.41 2.62 - 2.64	60.86 - 61.37 66.6 - 67.1
Guide OD	Intake and Exhaust	.6255 - .626	15.888 - 15.900
Guide ID	Intake and Exhaust	.374 - .375	9.50 - 9.53
Guide to Stem Clearance	Intake Exhaust	.001 - .003 .002 - .004	.03 - .08 .05 - .10
Exhaust Seat Insert OD		1.6270 - 1.6275	41.326 - 41.339
Exhaust Seat Insert ID		1.385 - 1.390	35.18 - 35.31
Exhaust Seat Insert Depth		.207 - 209	5.26 - 5.31
Intake Seat Angle and Exhaust Seat Insert Angle		30º - 30º 30’	
Guide Extend Above Head	Intake Exhaust	.834 - .854 .928 - .948	21.18 - 21.69 23.57 - 24.08
Guide Bore in Head		.6245 - .6250	15.862 - 15.875
Exhaust Seat Insert Counterbore Depth		.217 - .220	5.51 - 5.59
Intake Seat Insert Counterbore Depth		.260 - .261	6.60 - 6.62
Exhaust Seat Insert Counterbore Diameter		1.624 - 1.625	41.25 - 41.28
Intake Seat Insert Counterbore Diameter		1.8150 - 1.8155	46.10 - 46.11
Intake and Exhaust Seat Width		.080 - .100	2.03 - 2.54
Spring Free Length	Intake Exhaust	2-9/16 + 1/16 2-9/16 + 1/16	65.07 + 1.59 65.07 + 1.59
Valve Closed Spring Length	Intake Exhaust	1-29/32 @ 59 + 4# 1-29/32 @ 59 + 4#	48.45 @ 27 + 1.8kg 48.45 @ 27 + 1.8kg
Valve Open Spring Length	Intake Exhaust	1-1/2 @ 95 + 4# 1-1/2 @ 95 + 4#	38.25 @ 43 + 1.8kg 38.25 @ 43 = 1.8kg



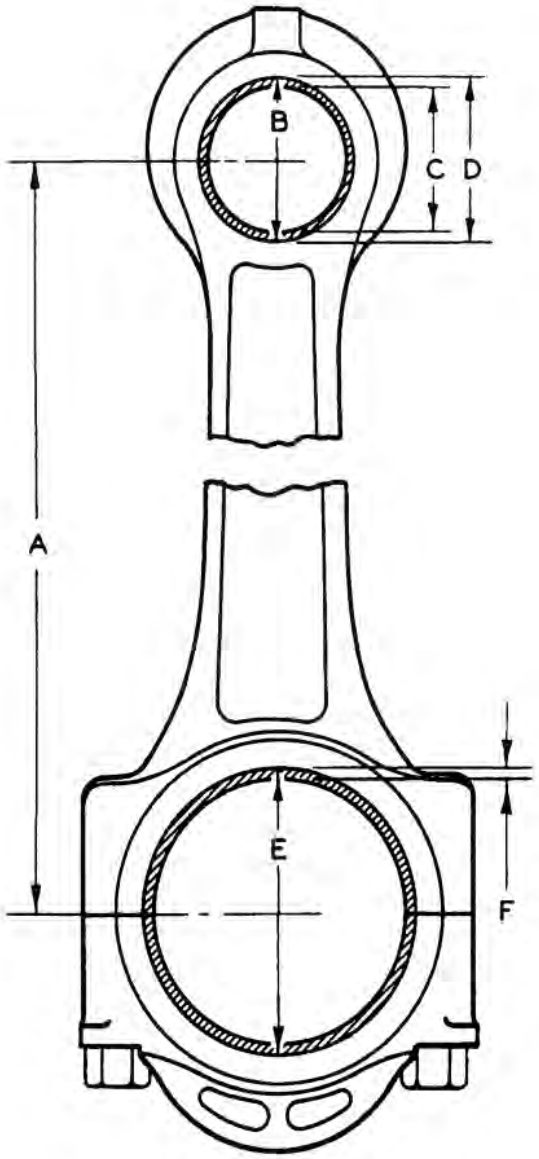
CAUTION

Compression rings of VR Series engines which are notched on the inner edge must be installed with the notch toward the top of the piston. Compression rings of VR Series engines which are notched on the outer edge must be installed with the notch toward the bottom of the piston. Some rings are stamped "TOP" or include a center punch mark which must be installed toward the top of the piston.

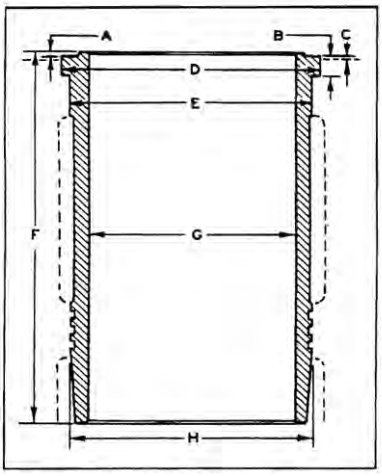
TYPICAL PISTON RING		
	VR220/330/330CF Inches (mm)	**VR330TA Inches (mm)**
A. RING GAP -		
Top	.010 - .023 (.25 - .58)	.012 - .025 (.31 - .64)
2nd	.010 - .023 (.25 - .58)	.010 - .023 (.25 - .58)
3rd	.010 - .023 (.25 - .58)	.010 - .023 (.25 - .58)
B. RING WALL -		
Top	.184 - .194 (4.67 - 4.93)	.158 - .168 (4.01 - 4.27)
2nd	.171 - .181 (4.34 - 4.60)	.158 - .168 (4.01 - 4.27)
3rd	.135 - .145 (3.43 -3.68)	.135 - .145 (3.43 -3.68)
C. RING WIDTH -		
Top	.0930 - .0935 (2.362 - 2.375)	Keystone Type
2nd	.0925 - .0935 (2.350 - 2.375)	.0930 - .0935 (2.362 - 2.375)
3rd	.186 - .187 (4.72 - 4.75)	.1860 - .1865 (4.724 - 4.737)
D. SIDE CLEARANCE -		
Top	.0025 - .0040 (.064 - .102)	Keystone Type
2nd	.002 - .004 (.05 - .10)	.002 - .004 (.05 - .10)
3rd	.001 - .003 (.03 -.08)	.0015 - .0035 (.038 - .089)



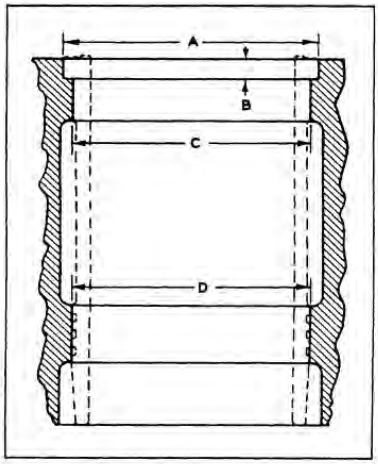
TYPICAL PISTON				
	VRG220/330/330CF		VRG330TA	
	Inches	(mm)	Inches	(mm)
PISTON PIN DIAMETER	1.2495 - 1.2497	(31.737 - 31.742)	1.2495 - 1.2497	(31.737 - 31.742)
A. Piston Pin Bore	1.2499 - 1.2502	(31.747 - 31.755)	1.2499 - 1.2502	(31.747 - 31.755)
PISTON PIN FIT	.0002 - .0007	(.005 - .018)	.0002 - .0007	(.005 - .018)
B. Running Clearance	.0023 - .0053	(.058 - .135)	.003 - .006	(.08 - .15)
C. Groove Width				
Top	.096 - .097	(2.44 - 2.46)	.096 - .097	(2.44 - 2.46)
2nd	.0955 - .0965	(2.426 - 2.451)	.0955 - .0965	(2.426 - 2.451)
3rd	.188 - .189	(4.77 - 4.80)	.188 - .189	(4.77 - 4.80)
D. Skirt Diameter	3.8707 - 3.8727	(98.316 - 98.367)	3.870 - 3.872	(98.30 - 98.35)



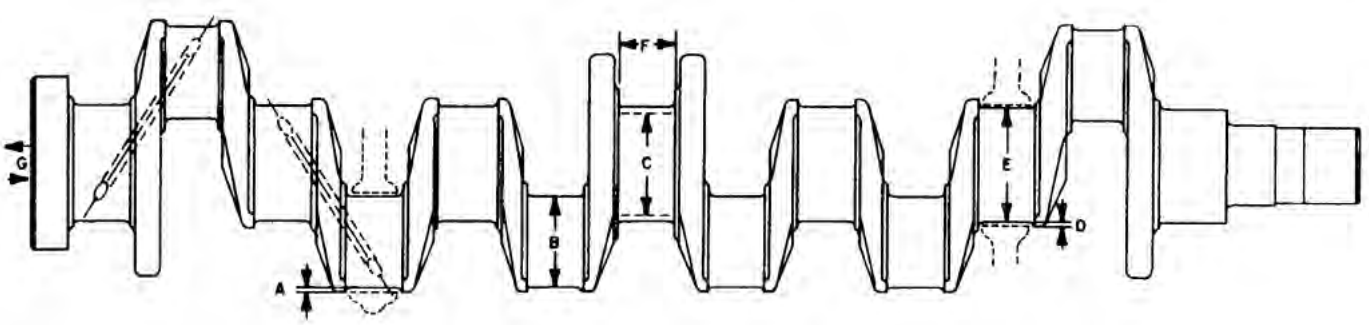
CONNECTING ROD		
	Inches	**(mm)**
A - Rod Length, Center to Center	6.999 - 7.001	(177.77 - 177.83)
B - Small End Finish Size	1.3745 - 1.3755	(34.912 - 34.938)
C - Bushing Bore Diameter	1.2501 - 1.2506	(31.753 - 31.765)
D - Bushing Press in Rod	.0035 - .0060	(.089 - .152)
E - Large End Finish Size	2.5883 - 2.5893	(65.743 - 65.768)
F - Bearing Wall Thickness	.07480 - .0135	(1.90 - 0.343)
Rod Side Clearance	1.3655 - 1.3675	(34.684 - 34.735)
Weight Variation Per Set	¼ oz.	(7.09 grams)
Bearing Running Clearance	.0007 - .0037	(0.018 - 0.094)



BUSHING		
	Inches	(mm)
A - Heat Dam Projection	.030 - .034	(.76 - .86)
B - Flange Height	.345 - .346	(8.76 - 8.79)
C - Sleeve Projection	.001 - .004	(0.03 - 0.10)
D - Flange Diameter	4.558 - 4.560	(115.77 - 115.82)
E - Sleeve Diameter Below Flange	4.290 - 4.300	(108.97 - 109.22)
F - Sleeve Length Less Heat Dam	7.620	(193.55)
G - Bore Diameter	3.875 - 3.876	(98.43 - 98.45)
H - Sleeve Diameter Lower Seal Area	4.277 - 4.279	(108.64 - 108.69)
Sleeve Bore Maximum Out of Round	.002	(.051)
Sleeve Bore Taper Maximum	.002	(0.05)
Sleeve Seal Area to Crankcase Diameter	.002 - .005	(0.05 - 0.13)

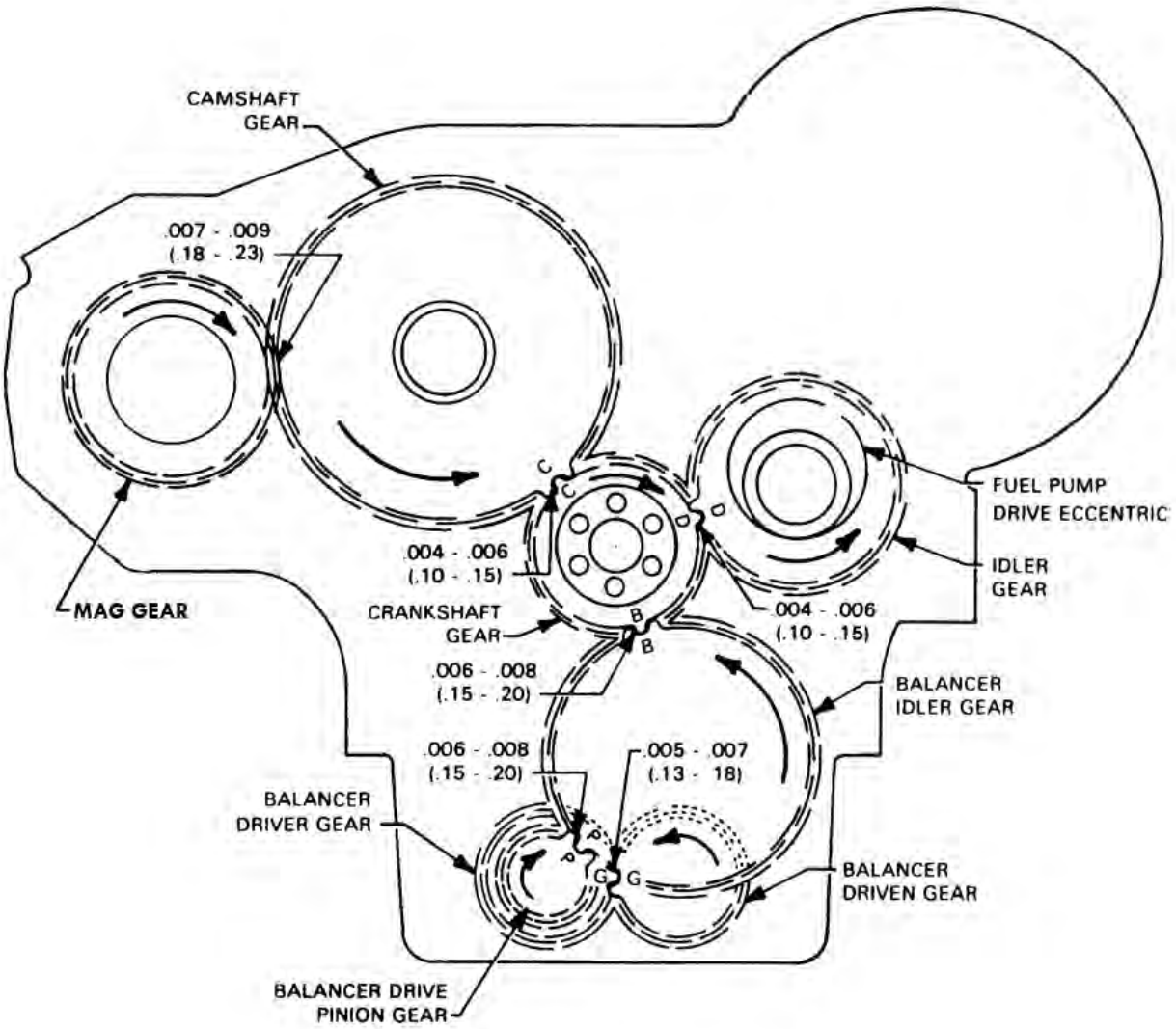


BEARING		
	Inches	(mm)
A - Counterbore Diameter	4.562 - 4.563	(115.87 - 115.90)
B - Counterbore Depth	.342 - .344	(8.69 - 8.74)
C - Case Upper Bore	4.370 - 4.380	(111.00 - 111.25)
D - Case Lower Bore	4.281 - 4.282	(108.74 - 108.76)
Main Bearing Journal Bore	3.191 - 3.192	(81.05 - 81.08)
Camshaft Bearing Bore	2.1245 - 2.1255	(53.962 - 53.988)
Camshaft Outboard Bearing Bore in Gear Cover (Special Application Only)	1.502 - 1.503	(38.15 - 38.18)

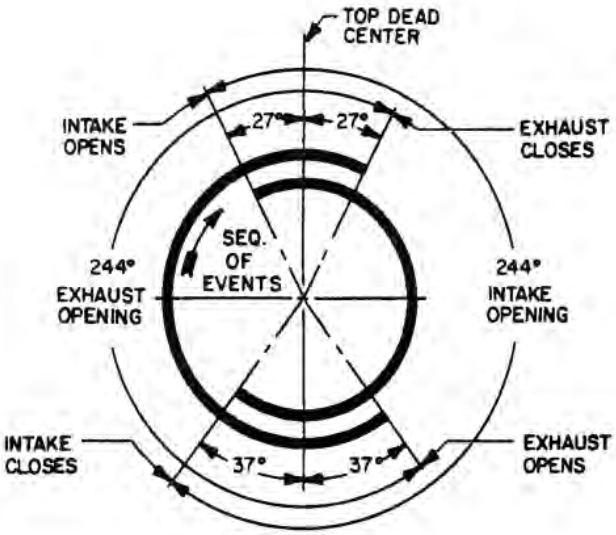


TYPICAL CRANKSHAFT		
	Inches	**(mm)**
A - Connecting Rod Bearing Running Clearance	.0007 - .0037	(.018 - .094)
B - Connecting Rod Bearing Journal Diameter	2.436 - 2.437	(61.87 - 61.90)
C - Main Bearing Journal Maximum Undersize	.020	(.51)
D - Main Bearing Running Clearance	.002 - .005	(.05 - .13)
E - Main Bearing Journal Diameter	2.9974 - 2.9984	(76.134 - 76.159)
F - Crank Thrust Length	1.5025 - 1.5045	(38.164 - 38.214)
G - Crankshaft End Play	.0045 - .0095	(0.114 - 0.241)
H - Connecting Rod Journal Width	1.375 - 1.379	(34.93 - 35.03)
Main and Rod Journal Maximum Taper	.0006	(.015)
Main Bearing Shell Thickness	.0943 - .09408	(2.395 - 2.408)
Thrust Bearing Width	1.495 - 1.498	(37.97 - 38.05)

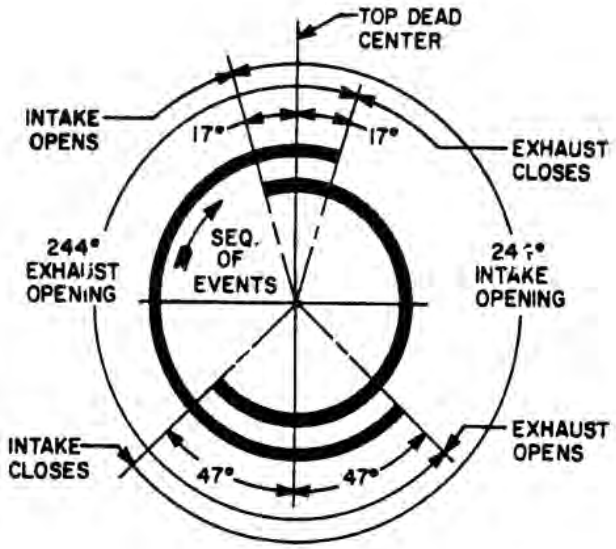
CAMSHAFT, VALVE LIFTERS AND ROCKER ARMS		
	Inches	**(mm)**
Cam Journal Diameter	2.000 - 2.001	(50.80 - 50.83)
Cam Journal Running Clearance	.002 - .004	(.05 - .10)
Cam End Play	.004 - .012	(.10 - .30)
Cam Bushing ID	2.003 - 2.004	(50.88 - 50.90)
Special Application Bushing ID	1.378 - 1.379	(35.00 - 35.03)
Cam Lift - Intake - Exhaust	.302 .302	(7.67) (7.67)
Thrust Plate Thickness	.176 - .180	(4.47 - 4.57)
Valve Lifter OD	.6240 - .6245	(15.850 - 15.862)
Valve Lifter Bore ID	.6250 - .6265	(15.875 - 15.913)
Valve Lifter Running Clearance	.0005 - .0025	(.013 - .064)
Rocker Arms - ID	.7445 - .7455	(18.910 - 18.936)
Rocker Arm Shaft - OD	.7425 - .7435	(18.860 - 18.885)
Rocker Arm Running Clearance	.001 - .003	(.03 - .08)


CAMSHAFT GEAR
.007 - .009 (.18 - .23)
MAG GEAR
.004 - .006 (.10 - .15)
CRANKSHAFT GEAR
.006 - .008 (.15 - .20)
FUEL PUMP DRIVE ECCENTRIC
IDLER GEAR
.004 - .006 (.10 - .15)
BALANCER IDLER GEAR
.006 - .008 (.15 - .20)
.005 - .007 (.13 - 18)
BALANCER DRIVER GEAR
BALANCER DRIVEN GEAR
BALANCER DRIVE PINION GEAR

BACKLASHES		
	Inches	**(mm)**
Crankshaft Gear to Camshaft Gear	.004 - .006	(.10 - .15)
Cam Gear to Mag Gear	.007 - .009	(.18 - .23)
Crank Gear to Idler Gear	.004 - .006	(.10 - .15)
Idler Gear to Governor Idler Gear	.004 - .006	(.10 - .15)
Governor Idler Gear to Governor Drive Gear	.007 - .009	(.18 - .23)
Crank Gear to Balancer Idler Gear	.006 - .008	(.15 - .20)
Balancer Idler Gear to Balancer Drive Pinion	.006 - .008	(.15 - .20)
Balancer Drive Gear to Driver Gear	.005 - .007	(.13 - .18)
Magneto Drive Gear to Idler	.007 - .009	(.18 - .23)



VALVE SEQUENCE DIAGRAM
(DIESEL AND PREVIOUS GAS)



VALVE SEQUENCE DIAGRAM
(CURRENT GAS)

TIMING GEAR SHAFTS AND BUSHINGS		
	Inches	**(mm)**
Governor Idler Spindle OD	9990 - .9995	(25.375 - 25.387)
Governor Idler Gear ID	1.002 - 1.003	(25.45 - 25.48)
Governor Drive Gear Bushing ID	1.002 - 1.003	(25.45 - 25.48)
Governor Drive Gear OD	.9990 - .9995	(25.375 - 25.387)
Magneto Gear ID	.8745 - .8755	(22.21 - 22.23)
Magneto Bushing OD	.8735 - .8745	(22.19 - 22.21)
Camshaft Bushing ID	2.003 - 2.004	(50.88 - 50.92)
Camshaft OD	2.000 - 2.001	(50.80 - 50.82)
Camshaft Outboard Bushing ID	1.378 - 1.379	(35.00 - 35.03)
Camshaft Extension OD	1.374 - 1.375	(34.90 - 34.93)
Idler Gear Bushing ID.	1.378 - 1.379	(35.00 - 35.03)
Idler Gear Spindle OD	1.3755 - 1.3765	(34.937 - 34.963)

FLYWHEEL HOUSING		
	Inches	(mm)
Pilot Bearing Bore Runout	.005	(.13)
Flywheel Face Runout	.008	(.20)
Flywheel Housing Bore Runout	.008	(.20)
Flywheel Housing Face Runout	.008	(.20)

OIL PUMP				
	216080A Series Oil Pump		216080C Series Oil Pump	
	Inches	(mm)	Inches	(mm)
Pump Gear Backlash	.010 - .014	(.26 - .35)	.010 - .014	(.26 - .35)
Drive Shaft Bushing ID (Top)	.4955 - 34965	(12.586 - 12.611)	No Bushing	
Drive Shaft Bushing ID (Bottom)	.6260 - .6265	(15.901 - 15.913)	No Bushing	
Oil Pump Body Running Surface ID (Top)	.743 - .744			(18.872 - 18.897)
Oil Pump Body Running Surface ID (Bottom)			.743 - .744	(18.872 - 18.897)
Drive Shaft Running Surface OD (Top)	.4940 - .4945	(12.548 - 12.560)	.7415 - .7420	(18.835 - 18.846)
Drive Shaft Running Surface OD (Bottom)	.6240 - .6245	(15.850 - 15.862)	.7415 - .7420	(18.835 - 18.846)
Idler Shaft OD	.6220 - .6225	(15.799 - 15.811)	.6220 - .6225	(15.799 - 15.811)
Idler Gear ID	.6255 - .6265	(15.888 - 51.913)	.6255 - .6265	(15.888 - 15.913)

METRIC CONVERSION FORMULAS

In order to convert the data in this manual into metric values, use the following conversion formulas. Examples of applying each conversion formula are included.

Less Than One (1) Inch to Millimeters
25.4 x Fraction in Decimal
Example: 2-5/8" = 2.625 x 25.4 = 66,675 mm

More Than One (1) Inch to Millimeters
25.4 x Inches and Decimal Fraction
Example: 2-5/8" = 2.625 x 25.4 = 66,675 mm

Cubic Inches to Liters
.01639 x Cubic Inches
Example: 9388 Cubic Inches = 9388 x .01639 = 153,8 Liters

Ounces to Grams
28.35 x Ounces
Example: 21 Ounces = 21 x 28.35 = 595,35 grams

Pounds to Kilograms
.4536 x Lbs.
Example 22,550 Lbs. = 22,550 x .4536 = 10,228 Kg

Inch Pounds to Newton-meters
Inch Lb. X .11298
Example: 360 In. Lb. = 360 x .11298 = 40,67 N-m

Foot Pounds to Newton-meters
Foot Lb. X 1.3558
Example: 145 Ft. Lb. = 145 x 1.3558 = 196,6 N-m

PSI to KG per Sq. Centimeter
PSI x .0703
Example: 45 PSI = 45 x .0703 = 3,16 KG per Sq. Centimeter

Ounces (fluid) to Cubic Centimeters
29.57 x Ounces
Example: 8 Ounces = 8x 29.57 = 236,56 cc

Gallons to Liters
Gallons x 3.7853
Example: 148 Gal. = 148 x 3.7853 = 560 Liters

Degrees Fahrenheit to Degrees Centigrade
Degrees Fahrenheit -32 x 5/9
Example: 212° F= 212 - 32 x 5/9 = 180 x 5/9 = 100° C

BASIC ENGINE DATA

	VRG220		VRG330	
Number of Cylinders	4		6	
Compression Ratios	8:1		8:1	
Firing Order	1 - 3 - 4 - 2		1 - 5 - 3 - 6 - 2 - 4	
Number of Main Bearings	5		7	
Engine Length Enclosed Unit	32” 45”	81.3 cm 114.3 cm	41.5” 54”	105.4 cm 137.16 cm
Engine Width Enclosed Unit	22.84” 32”	58.0 cm 81.3 cm	23.5” 32”	59.7 cm 81.3 cm
Engine Height Enclosed Unit	31” 46”	78.7 cm 116.84 cm	36.7” 46”	93.2 cm 116.84 cm
Lube Oil Capacity* (standard oil pan) With Filter only With Filter & Cooler (if applicable)	 7 qts. 7.5 qts.	 6.6 liters 7.1 liters	 8.5 qts. 9 qts.	 8 liters 8.5 liters
Coolant Capacity - Engine Only With Oil Cooler (if applicable)	 7 qts. 8 qts.	 6.6 liters 7.6 liters	 8.25 qts. 9.25 qts.	 7.8 liters 8.8 liters
Cylinder Compression @ Crank Speed (200 rpm)	170 - 200 psi	12 - 14 kg/cm²	170 - 200 psi	12 - 14 kg/cm²
Spark Plug Gap	.025”	.64 mm	.025”	.64 mm
Distributor Point Gap	.022”	.56 mm	.022”	.56 mm
Distributor Dwell Angle	32 - 36º		32 - 36º	
Valve Clearance - Cold Intake Exhaust	 .027 - .033” .027 - .033”	 .69 - .84 mm .69 - .84 mm	 .027 - .033” .027 - .033”	 .69 - .84 mm .69 - .84 mm
*Large capacity optional pans available for the VR330				

MAGNETO TIMING
VRG220 and VRG330

RPM	NATURAL GAS	LPG	GASOLINE
900 - 1400	20° BTDC	11° BTDC	4° BTDC
1500 - 1800	24° BTDC	18° BTDC	8° BTDC
1900 - 2200	30° BTDC	20° BTDC	18° BTDC
2300 - 2600	34° BTDC	24° BTDC	22° BTDC

DISTRIBUTOR TIMING
VRG220 and VRG330

RPM	NATURAL GAS	LPG	GASOLINE
450	10° BTDC	TDC	8° ATDC

NOTE: *Low idle for all VR220/330 is 800 rpm. For high idle, add 150 rpm to loaded speed.*

INSTALLATION

Scope

These are general installation requirements. For more specific requirements, contact the Customer Service Department at Arrow Engine Company.

Automatic Starting

We recommend the use of jacket water heaters for installations which are subjected to unscheduled automatic starts and instantaneous loading.

Space Requirements

In order to ensure adequate access for engine installation, ventilation and in-service maintenance, the engine location must be carefully considered.

The engines described in this manual require a minimum of 24 inches (60.9 cm) between the engines or between the engine and wall. End clearance required to remove the camshaft is 36 inches (91.4 cm). Sufficient overhead clearance is required to permit the use of a chain hoist for removal of heavy engine parts. The heaviest part of the VR220 engine is the short block which weighs approximately 460 lbs. (209 Kg). The VR330 short block weighs approximately 600 lbs. (272 kg).

Cover all engine openings until installation, to prevent foreign objects from entering the engine.

STATIONARY INSTALLATIONS

Engine Foundations

Most stationary engine applications require a foundation or mounting base. This base isolates the engine from the surrounding structure and absorbs or inhibits vibrations. A base provides a permanently accurate surface upon which the engine (and usually the driven equipment) may be mounted and aligned. To serve these purposes, the foundation must have a suitable size and mass, rest on an adequate soil or bearing surface, be provided with an accurately finished mounting surface for the engine, and be equipped with properly sized retaining bolts in the correct locations to secure the engine firmly in position.

Mounting

No engine will perform properly if incorrectly installed and aligned.

Any misalignment of mountings imposes stresses on the engine structure with possible damage to flywheel housing, flywheel, crankshaft and thrust bearings.

Because of the variety of power applications, the VR Series engines will be found mounted in both mobile and stationary applications. In all cases it is most important that proper mountings be selected for the specific application. If the engine and driven equipment have separate foundations, alignment is critical. To ensure proper alignment, inspect foundations for weld spatter, burrs, foreign matter or uneven surfaces. It is plainly a waste of time to attempt alignment if the foundation is not level and clean.

Alignment

It is always desirable to have shims under both the engine and driven equipment, so future alignment at time of rebuilding or replacement will not present a problem.

The nature of any shimming procedure is essentially “cut and try”. Use easily cut steel or brass shim stock to make up trial shim pads. Remember the area of the shim pad must be large enough to support the weight of the engine when the bolts are tightened.

After the engine has been leveled and tightened down, the driven equipment can be aligned. In the case where the driven equipment is mounted permanently, the engine will have to be aligned relative to the driven equipment.

When the engine and driven equipment are mounted on a common skid base, shims should be used under both units to compensate for roughness and unevenness of the skid rails. The will also provide shims under drive and driven units for final alignment. Usually the heaviest machine is permanently mounted and the lightest aligned to the heaviest.

The correct aligning procedure may vary slightly with different types of drive equipment. Many manufacturers of driven equipment will specify the method to be used to align their equipment. In general, the object is the same: to make the driven shaft concentric with the driver shaft.

If at all possible, steel chocks should be used to fill larger gaps so that only the last few thousandths of an inch need to be filled out with thinner shim stock.

Always use shims that are wide enough to permit the full base mounting area to bear on them.

The full width of the mounting base must be supported, not just the outer edge.

Preparing The Unit For Service

Inspect all identification and data plates and comply with all servicing instructions. Compare data plates with information contained in invoices or packing slips to ensure receipt of equipment as ordered.

Inspect entire engine for damage, loose connections, broken or sharply bent lines, and loose nuts or bolts. If tape or temporary coverings are torn or missing from engine openings (such as intake, exhaust, water or fuel), a thorough inspection will be required to determine the possible presence of foreign objects in these openings.

The steps needed to bring an engine into active service are basically the same for a new engine or one that has been in storage. In addition to a very detailed visual inspection, check for free rotation. Any accumulated dust and dirt should be wiped or washed from the exterior before removing engine opening covers. Engines that have not been rotated for some time should be oiled through the spark plug openings and cranked by hand before running. Any resistance to free cranking should be investigated; rust and corrosion can cause engine seizure that cannot be cleared without engine disassembly.

CAUTION

Never attempt to start an engine that has been stored without first inspecting the intake passages and manifolds for thickened preservative oil.

Crank the engine over with the spark plugs out. Oil, water or preservative compound trapped in the cylinders would lead to a hydraulic lock. Continue to crank engine with the starter until liquid is on longer ejected from the openings.

Fill the crankcase with the proper grade and viscosity of oil to the full mark on the oil level dipstick.

If conditions permit, the cooling system should be filled with soft water. After the cooling system has been checked and any leaks have been repaired, drain a portion of the water and add an inhibitor or antifreeze as required. Soluble oil may be used as an inhibitor. Use one ounce of oil per gallon of coolant. Check battery connections for proper polarity, Pour the acid into the dry batteries and see that the battery plates are covered with solution.

Connect the batteries and control wires. When a dry charge battery is used, the battery should be charged prior to use.

COOLING SYSTEM

Cooling System Design

Premature engine component failures and abnormal engine performance can often be traced to improper design or sizing of radiators or other coolers.

Arrow Engine Company will not be responsible for engine or component failure when the following cooling system design and application recommendations are not followed.

Recommendations for Specifying a Radiator or Other Cooler for Continuous Duty Operation

1. Base the water flow and temperature drop across the radiator core or cooler on the jacket water pump curve.

2. Pressure drop through the radiator core or cooler with full water flow at rated speed must not exceed 3 to 5 psi (.21 to .35 kg/cm2).

3. Allow a 15% reserve for variations in application and environment conditions, i.e., wind direction, dirt and debris. This 15% is in addition to normal cooling system design fouling factors.

4. If a 50-50 solution of ethylene glycol could be used, the radiator core or cooler area should be 15% reduction in the heat transfer coefficient for ethylene glycol when compared with water.

5. Select a radiator or cooler for the highest ambient or raw water temperature condition expected. For radiators, an allowance must be made for air temperature rise across the engine with a blower fan, or in the engine room if a suction fan is used.

6. Radiators and surge tanks must have 7 psi (49 kg/cm2) pressure caps.

7. Provision must be made for desertion of the coolant, such as a divided top tank or separate surge tank.

8. Provision must be made for a balance line connection to the suction side of the water pump to prevent pump cavitation.

9. An adequate coolant expansion area must be provided in the radiator or in a separate surge tank.

10. Maximum back pressure into the radiator or cooler should not exceed 5 psi (.35 kg/cm2) at 2000 rpm.

11. Maximum inlet head to the jacket water pump is 20 feet (6.1 m) of water.

Recommendations For Specifying A Radiator Or Other Cooler Design For Intermittent Or Standby Operation

Same as for Continuous Duty Operation, except:

1. Use 200° F. (93.3° C.) instead of 185° F. (85° C.) engine outlet temperature.

2. Allow a 5% instead of a 15% reserve for variations in application and environmental conditions.

Recommendation For Specifying A Radiator Or Other Cooler Design For Torque Converter Application

When the engine cooler is also used for cooling a torque converter, the core or cooler surface should be at least 30% larger than the core required for the engine alone.

For turbocharged engines please contact factory for radiator and aftercooler data.

Cooling System Capacity

To prevent rust when using water alone, either use a recommended corrosion preventive or inhibitor, or add one ounce of soluble oil for every gallon of coolant in the cooling system.

COOLING SYSTEM CAPACITY			
Ethylene Glycol	Radiator Glycerine (G.P.A.)	Freezing Points	
		°F	°C
16%	37%	20	-7
25%	55%	10	-12
33%	70%	0	-18
39%	81%	-10	-23
44%	92%	-20	-29
48%	100%	-30	-34

COOLING CAPACITIES - ENGINES ONLY (Does Not Include Radiator or Heat Exchangers)		
VR330 without oil cooler	8.25 qts.	7.8 liters
VR330 with oil cooler	9.25 qts.	8.8 liters
VR220 without oil cooler	7.0 qts.	6.6 liters
VR220 with oil cooler	8.0 qts.	7.6 liters

Cooling System Installation Recommendations

After the cooler installation is competed and prior to filling the cooling system, clean all dirt and welding spatter from low points in the system. Flush all accessible piping sections and the cooler to remove as must dirt as possible.

After filling the system, check closely for leaks. Tighten all clamps and fittings prior to engine start-up to avoid coolant loss at start-up.

The following installation suggestions are offered to improve cooling system performance and make future maintenance easier and quicker:

1. Mount all cooling system components with at least enough clearance to permit normal maintenance and to allow for removal and replacement of accessories at the front of the engine without having to disrupt the cooling system.

2. Use suitable couplings so portions of the cooling system can be disconnected and moved aside as a unit during engine repair and maintenance. This avoids removal of individual pieces of pipe and the need to “work backward” to reach a given connection.

3. Provide convenient drainage points to remove water from both fresh water and raw water systems.

4. Provide easy to open accessible air vents to bleed air from cooling system piping and allow for immediate priming of the system.

5. Mount all belt-driven auxiliary water pumps so belts can be tightened easily. Locate pump couplings and drive pulleys so packing can be removed and replaced without major disassembly or pump removal.

6. Keep the system clean!

7. Avoid electrolysis; use zinc anodes or other cathodes for system protection.

Air Intake System

Huge quantities of air are required for all internal combustion engines. Exact combustion air requirements for VR Series engines can be obtained from Arrow EngineCompany.

Certain factors must be considered to ensure an adequate supply of clean combustion air. These are as follows:

1. Air requirements for engines installed in heated, air conditioned buildings may upset heating and ventilating calculations unless combustion air is supplied via an external air inlet.

2. If an external air inlet is required, it must be suitably designed to supply intake air in the proper temperature range (high intake air temperature results in power loss while extremely cold intake air may hinder starting of automatic standby units). It must also be designed to prevent pick-up of exhaust gas materials or exhaust from other industrial operations (such as foundry dust or paint spray), to prevent pick-up of flammable vapors, and to prevent entry of rain and water.

3. All ducting, as well as air cleaner to manifold connections, must be airtight to avoid drawing in unfiltered air.

4. The restriction through the air intake system must be kept to a minimum. Air duct restriction must never exceed two inches (50.8 mm) of water column. Restricted inlets, sharp or numerous bends and undersized ducting will all increase restriction unnecessarily.

5. Engine heat radiation will affect ambient air temperatures in building installations. Properly located intake and exhaust fans may be required to ventilate engine rooms.

Exhaust System

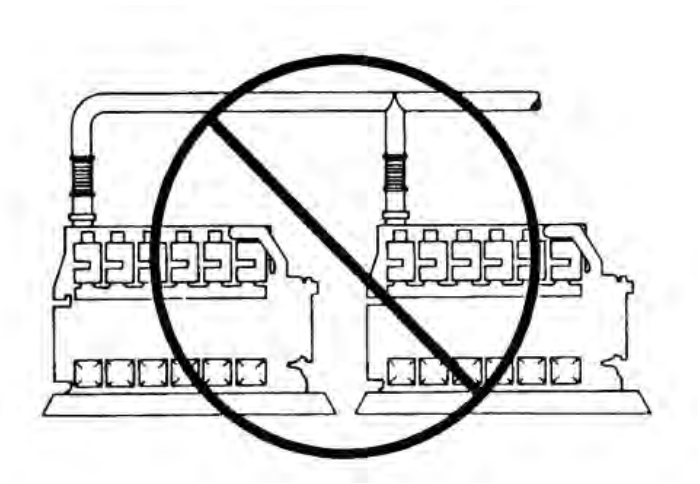
The huge quantities of combustion air consumed by the engine must be efficiently removed after combustion occurs. Therefore, every possible provision must be made to minimize exhaust system back pressure.

The maximum allowable back pressure for a VR Series engine is 20 inches (508 mm) of water column.

Some of the adverse effects of excessive back pressure are loss of power, smoking, poor fuel economy, excessive valve temperatures and engine coolant overheating.

If exhaust back pressure is found to be excessive, check for undersized piping, undersized or inefficient silencer or muffler, or excessive bends or restrictions in the exhaust line. Modify as necessary.

Exhaust pipes must be adequately sized and supported. A condensate trap and drain must be provided at some low point ahead of the engine exhaust manifold. The pressure restrictions caused by elbows and other pipe bends prohibit their use in a well designed exhaust system. Always use welded tube turns with a radius of four or five diameters. Multiple exhaust connections to a common header are not recommended, since this can result in erratic operation and engine damage. Never connect the exhaust system of more than one engine.



It is advantageous in every installation to locate the silencer as close to the engine as possible.

Attention must be given to adequate silencing of the engine, since unnecessary noise is a public nuisance. Objectionable noise is unnecessary today because of the available mufflers which can be used for silencing.

Before using any vent passage or chimney in an existing structure not specifically designed for service as an engine exhaust passage, it should be carefully checked for compliance with all fire and building codes. Do not discharge engine exhaust into a brick, tile, or cement block chimney, or structure of like material. The characteristics of the exhaust pulsations could cause severe structural damage.

Exhaust flow requirements for VR Series engines can be obtained from you Arrow sales engineer.

Lubrication Oil System

Lubricating oil specification recommendations are contained in the Preventive Maintenance unit. The installation should include adequate provisions for draining lube oil.

Angular Operating Limits

Angular operating limits must be adhered to for successful operation in any engine application. Users should be cautioned when job requirements are such that the engine might be tilted. Obviously, loss of oil pressure, even for brief periods, can have destructive results. The maximum angular operating limit for all VR220/330 engines is 25° in any direction for intermittent periods only.

LUBE OIL CAPACITIES		
VR330 with filter only	8.5 qts.	8 liters
VR330 with filter and cooler	9.0 qts.	8.5 liters
VR220 with filter only	7.0 qts.	6.6 liters
VR220 with filter and cooler	7.5 qts.	7.1 liters

Natural Gas Fuel System

Generally, natural gas is supplied by utility owned lines that run to the installation site.

The major components in the natural gas fuel system are the regulators, piping and the carburetor.

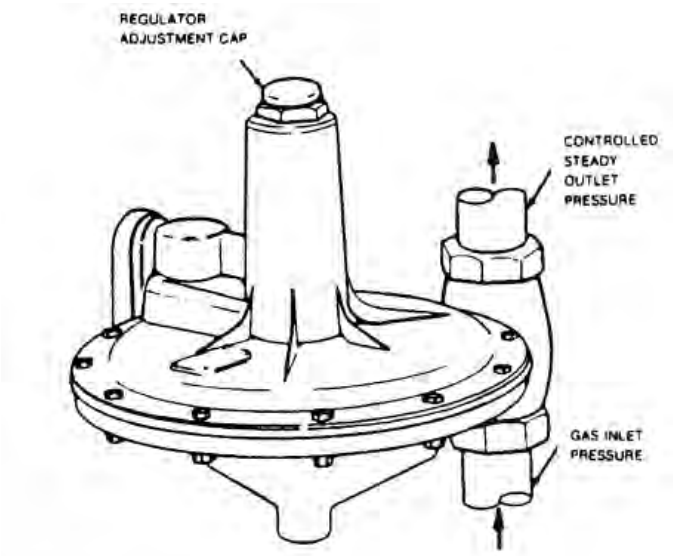
Pressure regulators are designed to control the pressure of the gas as it enters the engine. Through an arrangement of a diaphragm and springs, the pressure of the natural gas coming to the engine is lowered and controlled. This supplies a constant steady supply of gas to the carburetor.
There are two types of pressure regulators in the fuel system: a high pressure line, or “Big Joe”, regulator mounted near the main fuel line, and a low pressure engine regulator.

The line regulator brings the pressure in the lines leading to the engine regulator to 5-10 psi (.35 - .70 kg/cm2). The engine regulator sets the gas pressure to the carburetor at 5” + ½” (127 + 13 mm) of water column (less than 1 psi). From he engine mounted regulator the gas flows into the carburetor. Air is mixed with the gas, and it flows into the engine to be burned.

Gas pressure to this engine regulator must be 5-10 psi (.35 - .70 kg/cm2). Low gas pressure will starve the engine of fuel and reduce engine output. High pressures could damage the regulator, allowing excessive fuel to flood the cylinders. This could lead to detonation and serious engine damage.It at possible, avoid fueling any gas operated equipment off of the supply line between the line regulator and the engine regulator. The supply pressure to the engine could be disrupted. If there is no way to avoid such an installation, add a second line regulator close to the engine and increase the pressure from the first line regulator by 10 psi (.70 kg/cm2) to compensate for the pressure loss.

Regulators must be spaced according to the inner diameter of the pipe used. For a general rule of thumb, the maximum allowable distance between regulators is eight times the pipe ID. [For example, with a 2” pipe, the maximum distance between the regulators is 16” (406.4 mm)]. Regulators must be mounted in an upright position.

The maximum pressure drop across a line regulator is generally 50-75 psi (3.5-5.3 kg/cm2). Consult the regulator manufacturer for specific information.



NATURAL GAS REGULATOR

Checking Flywheel And Housing Runout And Crankshaft End Play

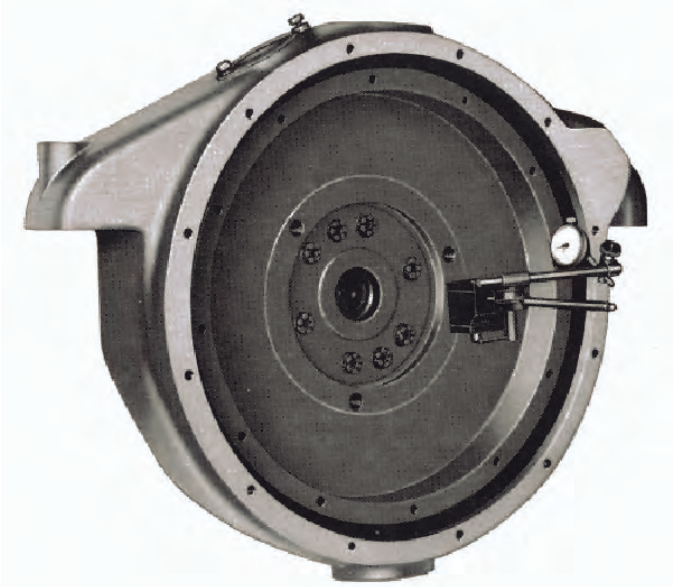
Even with the best maintenance, an engine can encounter trouble if such things as proper mounting, alignment with other equipment, flywheel and housing runout and sufficient crankshaft end play are disregarded in the initial installation or in subsequent engine relocations. Although flywheel and flywheel housing runout and crankshaft end play are firmly established within limits at the factory, such things as rough handling or improper installation of power takeoffs or clutches may adversely affect these clearances. These items should always be checked prior to engine start-up.

A major factor in obtaining long service life from any engine and clutch, or power take-off assembly, is the proper alignment of the flywheel housing, flywheel and pilot bearing bore. Distortion or lack of a common center on either of these parts will set up destructive forces to bearings, crankshaft, clutch, and the driven equipment.

In addition, because of normal manufacturing tolerances, when an engine is installed in a mounting formerly occupied by another engine, it is not safe to assume that the drive shaft of the power take-off will automatically line up with a coupling located for the previous engine. In such circumstances, either the engine mounts must be shimmed or adjusted, or the driven mechanism must be relocated and adjusted a few thousandths of an inch to bring the entire drive line from crankshaft bearings to driven shaft coupling into good alignment.

Make the following check for flywheel housing bore concentricity:

1. Support a dial indicator as shown and check the runout of the housing bore all the way around.



CHECKING HOUSING BORE RUNOUT

2. If the flywheel housing is out of alignment, loosen all of the flywheel housing bolts and proceed as follows.

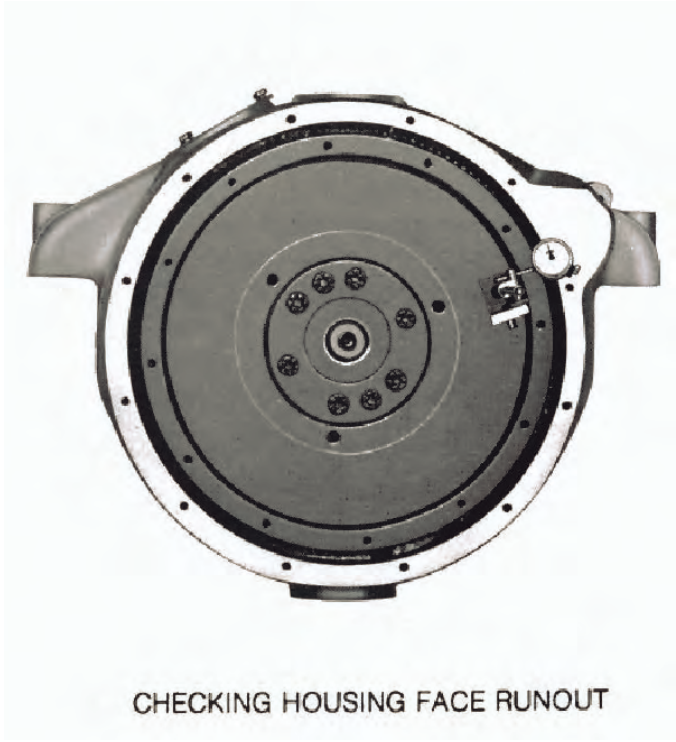
3. Use a small bar inserted in a bolt hole to correct misalignment until the runout does not exceed .008" (.203 mm) total indicator reading. If the misalignment cannot be corrected in this manner, the housing may have to be redoweled.

4. Tighten bolts partially, working back and forth across the housing. Recheck flywheel housing bore concentricity with a dial indicator.

Relocate the dial indicator as shown to indicate the flywheel housing face.

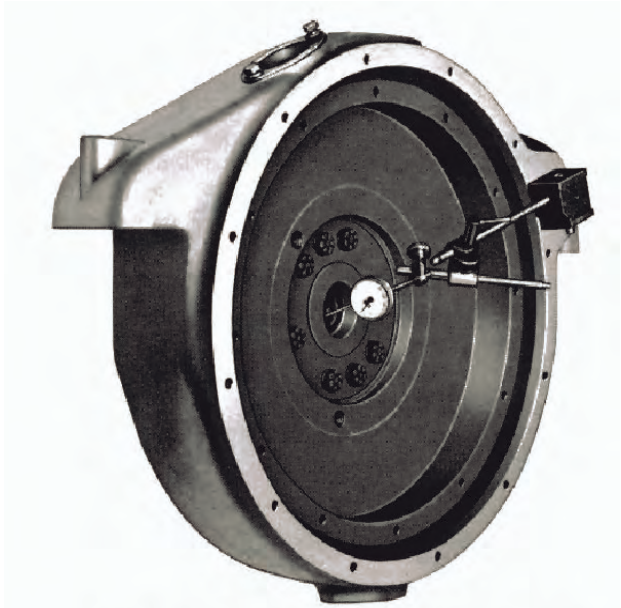
1. Housing face runout should not exceed .008" (.203 mm) total indicator reading. If correction is required, it should be done with a cutting tool mounted on a radial arm and firmly attached to the flywheel. Thus, by rotating the crankshaft by means of a suitable drive, the cutting tool will dress the housing face into a plane in alignment with the crankshaft flange.

2. When making the above inspection, it is very important not to be misled by the end play of the crankshaft. To prevent this, use a pry bar to bring the shaft into full forward position at each point where the indicator reading is taken.



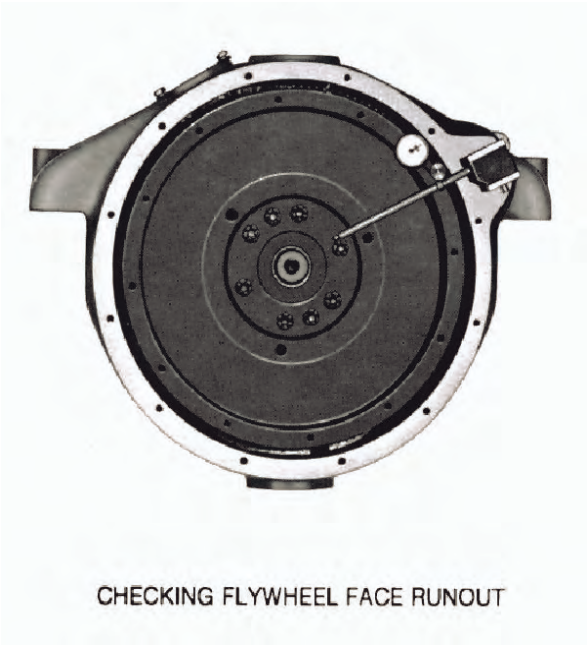
CHECKING HOUSING FACE RUNOUT

Mount a dial indicator on the flywheel housing as shown and check the runout of the pilot bearing bore. Runout should not exceed .005" (.127 mm) total indicator reading.



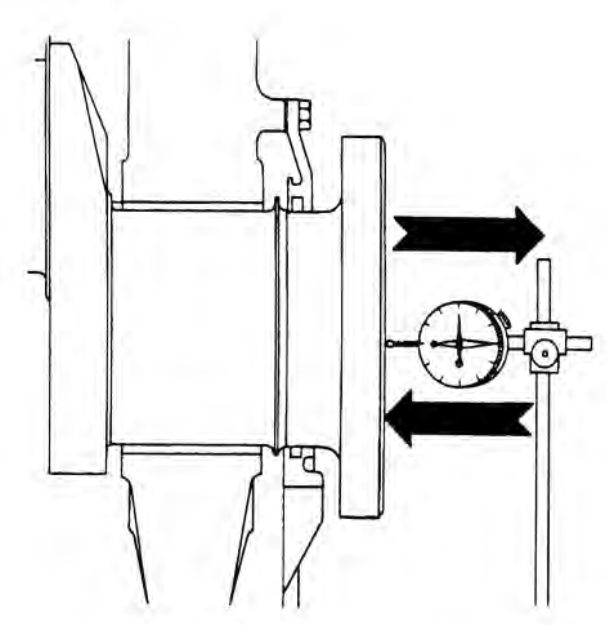
CHECKING PILOT BEARING BORE RUNOUT

Remount the dial indicator as shown to measure the runout of the flywheel face. Again, it is emphasized that each reading must be taken with the crankshaft moved all the way forward. Unless rough handling has somehow distorted the wheel or crankshaft flange, maximum runout should not exceed .008" (.203 mm) total indicator reading.



CHECKING FLYWHEEL FACE RUNOUT

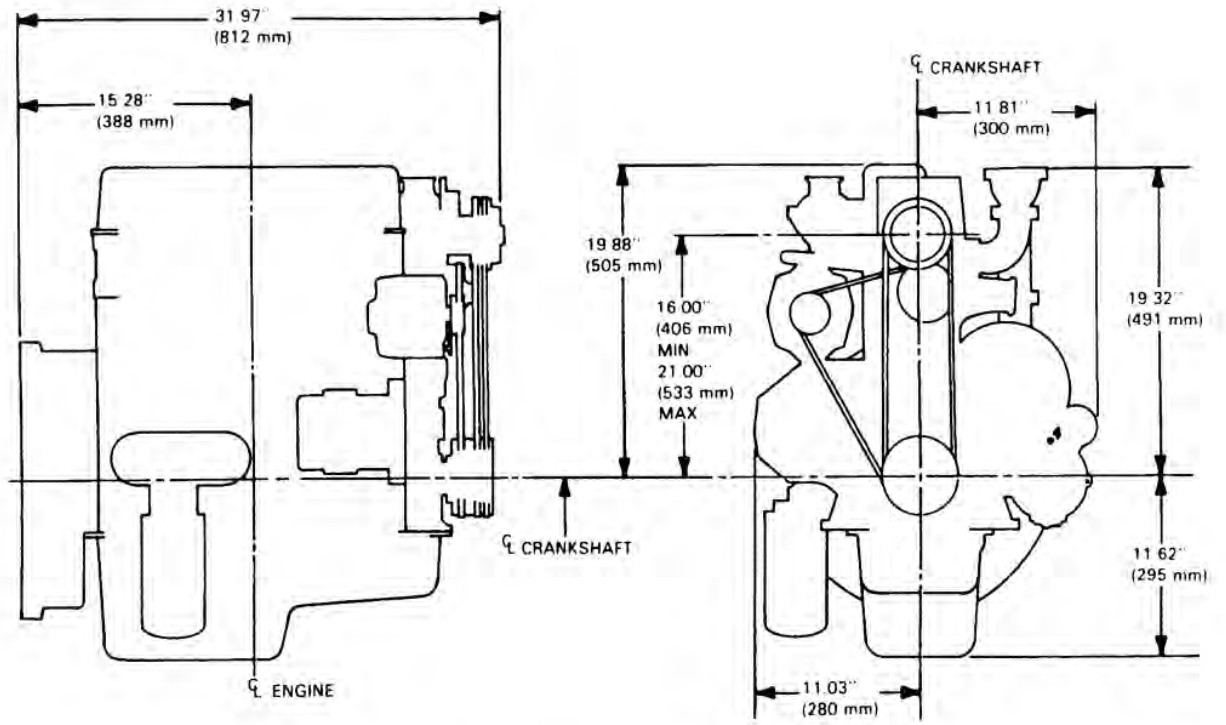
Measure crankshaft end play with a dial indicator mounted on the crankcase. Use a small pinch bar to move the crankshaft fully forward. Set the indicator at zero and use the bar to thrust the shaft to fully rearward. Check the end play reading on the dial indicator. End play must be within .0045 - .0095 inches (0.1114 - 0.241 mm).



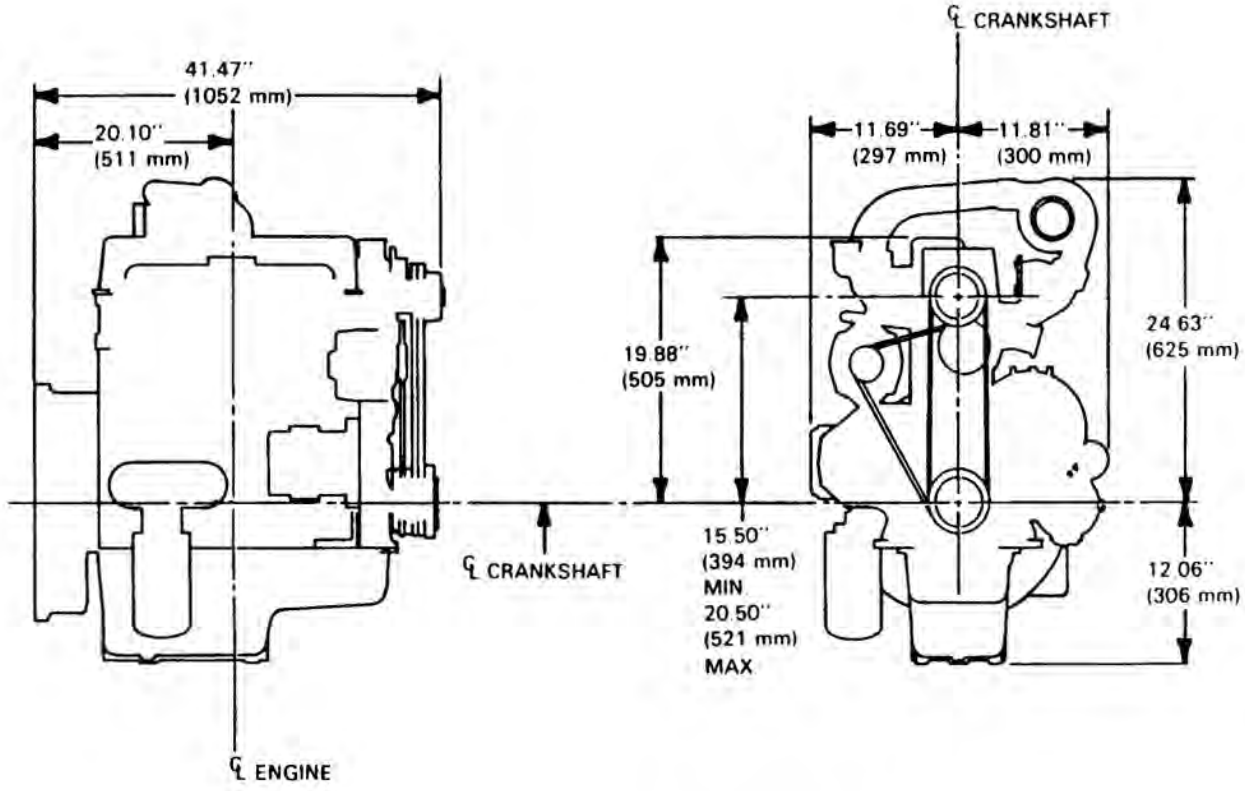
CHECKING CRANKSHAFT END PLAY

CAUTION

The importance of correct crankshaft end play cannot be overstressed. Operation of an engine having insufficient or excessive crankshaft end play can result in serious damage. Insufficient clearance will prevent proper lubrication of the thrust surfaces, causing the main bearings to overheat and lock on the shaft.



VR220 INSTALLATION DIMENSIONS



VR330 INSTALLATION DIMENSIONS

SUGGESTED SERVICE AND MAINTENANCE SCHEDULE

An easy, inexpensive way to reduce production costs on pumping wells is to properly maintain the pumping engine. Periodic preventive maintenance will extend the life of the engines by two to three times, and substantially reduce repair costs.

	DAILY	WEEKLY	MONTHLY	3 MOS.	6 MOS.	ANNUALLY
Visually check oil level	X					
Visually check water level	X					
Visually check fan belt tension			X			
Check Clutch adjustment (Clutch should snap in and out firmly)			X			
Inspect ignition wiring			X			
Visually check drive belt tension (Belts should not flop or slip)			X			
Lubricate clutch main bearing					X	
Lubricate clutch release bearing (One or two shots w/grease gun)					X	
Change oil			500hrs			
Check valve clearance			X			
Clean & gap spark plug			X			
Lubricate clutch pilot bearing (One or two shots w/grease gun)					X	
Check governor lubrication (Remove oil line at governor to ascertain flow)			X			
Clean and flush cooling system						X
Clean air cleaner			X			
Clean breathers			X			
Visually inspect condenser fins for dirt and lint			X			
Change filter			X			
	DATES PERFORMED					
Oil change						
Filter change						
Clean air cleaner						
Clean and flush cooling system						
Install new clutch plates						
Clean engine exterior						

VR Continuous Duty ENGINE WARRANTY

CONTINUOUS DUTY DEFINITION: The highest load and speed which can be applied, subject to Arrow Engine Company's ratings in effect at time of sale. Please contact Customer Service if you need the Stand-By Duty Warranty

I. TERMS OF EXPRESS LIMITED WARRANTY

Arrow Engine Company warrants that it will repair or replace, at its election and expense, any part of an engine, or product (hereinafter referred to as "Products") manufactured by Arrow Engine Company, which proves to have had a defect in material or workmanship.

II. TERM LIMITATIONS OF EXPRESS LIMITED WARRANTY

A. This coverage shall commence upon initial new Products start-up date and shall expire upon the earlier of the following:
I. 1 year after the initial new Products start-up date; or
II. 18 months after the original shipment date of the covered Products by Arrow Engine Company.

III. ARROW ENGINE COMPANY'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Arrow Specialty Company shall be responsible for:

A. The repair or replacement, at Arrow Engine Company's election of covered defective parts and all reasonable labor required regarding a warranted failure during the express limited warranty and term. All such labor shall be provided by Arrow Engine Company's authorized contractor or distributor.
B. Reasonable and necessary travel (total mileage not to exceed 300m) and expenses incurred by Arrow Engine Company's authorized contractor or distributor.
C. Replacement of lubricating oil, coolant, filter elements, or other normal maintenance items that are contaminated and/or damaged as a direct result of a warranted failure.

NOTWITHSTANDING THE FOREGOING, ARROW ENGINE COMPANY SHALL NOT BE RESPONSIBLE FOR LABOR COSTS ASSOCIATED WITH WARRANTY CLAIMS.

IV. OWNER/DISTRIBUTOR'S RESPONSIBILITIES UNDER THE EXPRESS LIMITED WARRANTY

Owner shall be responsible for:

A. The operation and maintenance of the Products within the guidelines established by Arrow Engine Company while under the warranty period.
B. Making the Products available to Arrow Engine Company or Arrow Specialty Company's authorized contractors or distributors for any warranty repair, during normal business hours.
C. All additional costs incurred for premium or overtime labor, should owner request that repairs be mad eon a premium overtime schedule.
D. All costs incurred as the result of removal or reinstallation of the Products as may be required to effect any warranted repair.
E. All administrative costs and expenses resulting from a warranted failure.
F. Any costs of transportation, towing, repair facilities, or associated costs.
G. Loss of revenue and loss of/or damage to real and/or personal property.
H. Compliance with all local, state and federal laws.

V. LIMITATION OR ARROW ENGINE COMPANY'S OBLIGATIONS

The obligations of Arrow Engine Company under this express limited warranty shall be waived and voided, and Arrow Specialty Company shall not, thereafter, be responsible for:

A. Any failure resulting from owner or operator abuse or neglect, including but not by way of limitation, any operation, installation, application, or maintenance practice not in accordance with guidelines or specifications established by Arrow Engine Company; or
B. Any failure resulting from unauthorized modifications or repairs of the Products or;
C. Any failure resulting from overload, overspeed, overheat, accident, improper storage; or
D. Failure of owner to promptly provide notice of a claimed defect - all warranty claims must be authorized, documented, and submitted within 30 days of the failure date while under the warranty period; or
E. Failure of Products for which Arrow Engine Company did not receive properly completed start-up reports; or
F. Repairs of a covered failure performed with non-genuine Arrow Engine Company parts; or
G. Repairs of a covered failure performed by non-authorized contractors or distributors; or
H. Failure to make Products available to Arrow Engine Company or its authorized representatives, or
I. Failure to supply documents such as drawing and specifications relating to the specific application of the Products.

VI. APPLICABILITY AND EXPIRATION

The warranties set out above are extended to all owners in the original chain of distribution. The warranties and obligations of Arrow Engine Company shall expire and be of no further effect upon the dates of expiration of the applicable warranty periods.

The foregoing sets forth Arrow Engine Company's only obligations and owners' exclusive remedy for breach of warranty, whether such claims are based on breach of contract, tort (including negligence and strict liability), or other theories, and the foregoing is expressly in lieu of other warranties whatsoever expressed, implied, and statutory, including without limitation, the IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.

Notwithstanding the preceding, in no event shall Arrow Engine Company be liable for any direct, special, incidental or consequential damages (whether denominated in contract, tort, strict liability, negligence or other theories) arising out of this Agreement or the use of any Products provided under this Agreement.

Any action arising hereunder or relating hereto, whether based no breach of contract, tort (including negligence and strict liability), or other theories must be commenced within one (1) year after the cause of action accrues or it shall be barred.

ARROW MANUFACTURED

REPLACEMENT PARTS

Caterpillar® Engines

G379 G3304
G398 G3306
G399

Waukesha® Engines

F2895 P9390
F3521 145G/F817
F5108 140G/F554
L5790 WAK/1197
L7042

Gemini® Engines

G26 G40
Compressor Parts

Fairbanks® Engines

ZC-118 ZC-503
ZC-208 ZC-739
ZC-346

Ajax® Engines

5 x 6½
EA-22, 6½ x 8 CMA
EA-30, 7¼ x 8 CMA
E-30, 7½ x 10 CMA
E-42, 8½ x 10 CMA
DP-60, 9½ x 10 CMA
DP-70/80/160, 11 x 14 CMA
DP-115/230, 13¼ x 16

Piston & Rod Assemblies
180
360
600
800

Arrow Engine Company is in no way associated with Caterpillar®, Ford®, Fairbanks®, Ajax®, Gemini® or Waukesha®. All manufacturers' names and descriptions are for reference only.

OEM

C-Series

*C-46 *C-96
*C-66 *C-101
*C-106 *C-255

VR-Series

VR-155 VR-310
VR-220 *VR-330
VR-232 *VR-330CF
*VR-260 VR-265
VR-283 *VR-380

A-Series

*A42 *A54 *A62

*K6 Slow Speed Engine

Lufkin Engines

L-333 L-1770
*L-795 L-2165

Witte Engines

98 E15 F32
B12 E20 F42

Arrow Chemical Pumps

*10 Series (beam operated)
*12 & 13 Series (pneumatic)
*430 Series (electric)
*500 & 510 Series (pneumatic)
*Solar Chempump

*VRC-2 Gas Compressor

Gas Products

*Volume Tanks
*Vertical & Horizontal Separators
*Suction Scrubbers
*Meter Runs
*Coalscers
*Skids

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a TRIMAS company

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